DRAGON PORTLAND CEMENT

USED XX YEARS

USED XX YEARS

CUMBERLAND HYDRAULIC CEMENT & MFG. CO.
THIRD NATIONAL BANK BLDG., CUMBERLAND, MD.

MANUFACTURED BY
LAWRENCE PORTLAND CEMENT COMPANY

USED XX YEARS

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DRAGON PORT-LAND CEMENT

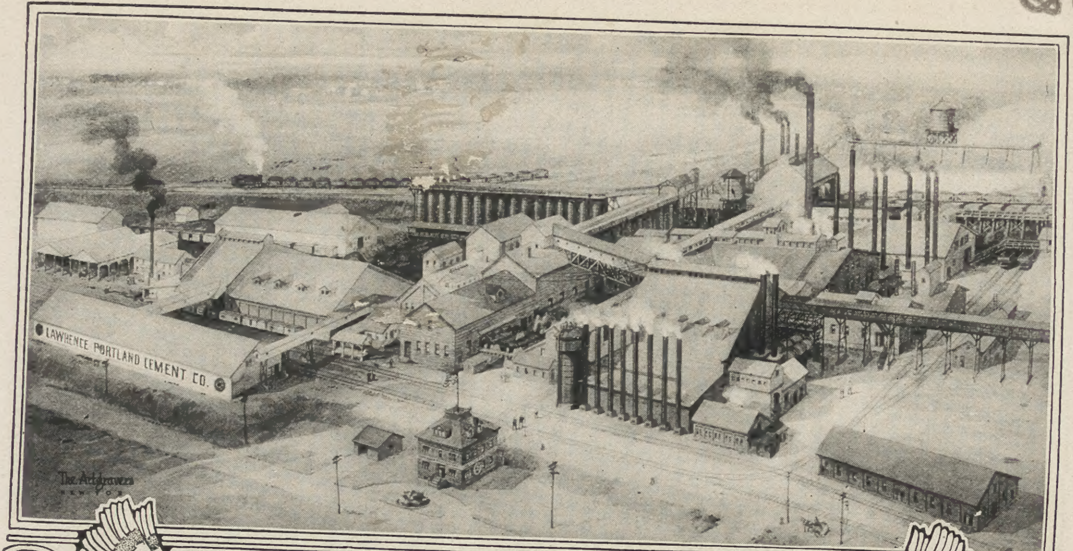
MANUFACTURED BY
LAWRENCE·PORTLAND CEMENT COMPANY

1889 1909

Used over Twenty Years

SALES OFFICES
THE·LAWRENCE·CEMENT·CO
Nº 1 BROADWAY · NEW·YORK
and
LAWRENCE·PORTLAND·CEMENT·CO
HARRISON·BUILDING·PHILADELPHIA

1909 Edition



WORKS of LAWRENCE PORTLAND CEMENT CO,

THE CEMENT rock from which "DRAGON" Portland cement is made was discovered 1821-1829 by the Lehigh

Coal & Navigation Company at Siegfried's Bridge, Northampton County, Pennsylvania, while surveying and building their canal through the Lehigh Valley. This immediate section of Pennsylvania became afterwards, in 1875, the birthplace of the American Portland Cement industry. Up to that date a very small quantity of natural cement only had been made from this rock, and the first Portland cement made from this deposit, about that time, amounted to less than two thousand barrels for that year's output. From this small beginning the Portland cement industry has grown to its present proportions of 51,002,612 barrels manufactured in 1908 in the United States. Of this quantity, the Lawrence Portland Cement Company produced its full proportion and takes pleasure in presenting to all cement users the following notes concerning a very few of the many uses to which its cement has been put, together with historical notes, proofs of the superiority of "Dragon" Portland cement, and some practical suggestions relating thereto.

63091

Ancient: Egyptians, Mexicans, Peruvians and the Greek colonists in Italy, used lime, more or less hydraulic in nature in much of their work.

500 B. C. Traces of Roman works using cementing materials, lime and puzzolona.

27 B. C. Dome of Pantheon, 142 feet in diameter, built by Agrippa, is of concrete, using lime and puzzolona.

1100 A. D. Foundations of Salisbury Cathedral built of concrete, using lime and other cementing materials.

1485 Alberti describes mortar.

1568 Phillibert de L'Orme describes use of lime with river sand.

1570 Palladio describes uses of forms, cement, etc.

1756 Smeaton used hydraulic lime in building the Eddystone Lighthouse.

1791-6 Patents granted Parker in England for "Roman Cement," (a highly limed natural cement).

1796 The manufacture of natural cement commenced in England.

1802 Natural cement produced in small quantities in France.

1810 Patent granted Dobbs in England for Roman cement.

1813 Vicat commenced extensive manufacture from clayey limestone of artificial hydraulic cement in France.

1818 Discovery in United States of suitable rock for making natural cement during construction of Erie Canal. This was manufactured by White and sold for 20 cents a bushel.

1821-1829 DISCOVERY AT SIEGFRIED'S BRIDGE, NORTHAMPTON COUNTY, PA., OF SUITABLE ROCK FOR MAKING NATURAL CEMENT.

1822 Frost commenced manufacture of artificial hydraulic cement in England.

1825 Cement rock discovered in Ulster County, New York, and natural cement manufactured there during the next year.

1828 Thames tunnel constructed using Portland cement.

1828 A cement mill was built at Rosendale, New York.

1829 Rock discovered near Louisville, Ky., and almost immediately thereafter manufacture commenced.

1832 The LAWRENCE CEMENT COMPANY commenced producing NATURAL CEMENT at Creek Locks in a converted grist mill.

1845 About this date manufacture of cement established on a scientific basis.

1846 Discovery at Boulogne-sur-Mer of natural rock suitable for cement.

1850 Cement manufactured at Siegfried's Bridge.

1852 Mill for manufacture of Portland cement erected at Stettin, Germany.

1866 Saylor commenced manufacture of cement at Coplay, Pa., near Siegfried's Bridge, and commenced experimenting on methods of improving the quality of the output.

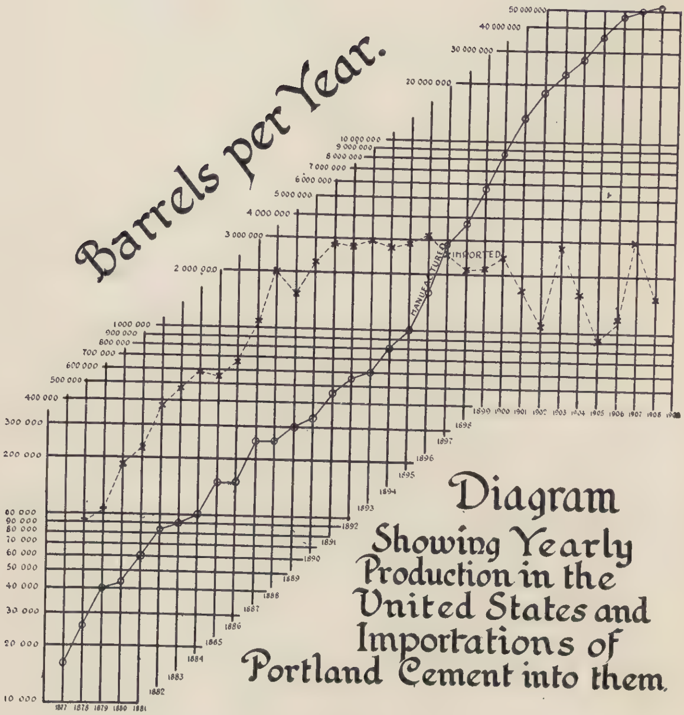


Diagram
Showing Yearly Production in the United States and Importations of Portland Cement into them.

1872 Portland cement manufactured from marl and clay near Kalamazoo, Michigan.

1875 First true Portland cement produced in Lehigh District, United States, by Saylor.

1875 A mill started at Washington, Pa., to use limestone and clay.

1887 MANUFACTURE OF " DRAGON " PORTLAND CEMENT COMMENCED.

1899 Over 100 cement plants producing in Germany.

1902 Establishment of the Association of American Portland Cement Manufacturers.

"" Of the six works started prior to 1881 half that number were failures and represented a complete loss to their promoters."

"" From this time on (1883) plants sprung up rapidly in the Lehigh Valley section, among the older ones being the LAWRENCE, all of these now being important producers."—(Meade, Portland Cement, p. 10.)

"" The plant of the LAWRENCE PORTLAND CEMENT COMPANY is located in the Lehigh District at Siegfried, Pa., about seven miles above Allentown, on the Central Railroad of New Jersey. The original plant located here was one of the first mills erected in this country, and manufactured both hydraulic cement and Portland cement."—(The Cement Industry—Latbury & Spackman in Engineering Record.)

THE JOURNAL

MONUMENTS TO A CEMENT.

Big Buildings In and Out of New York Testify to Durability of Dragon.

New York, Dec. 19.—In curious contradiction to the well-grounded belief that time changes all things, the Lawrence Cement Co., which furnished the cement for the old Custom House on Wall street, is to furnish Dragon cement for the new Custom House, just south of Bowling Green, proving conclusively that in this instance merit has not changed.

The Lawrence Cement Co. is what Wall Street calls an "old-timer," for it has been in existence more than 70 years. Its product—Dragon cement—was selected by the Federal Government for use in the construction of various buildings. It was used in the Chamber of Commerce's new home and in the East River bridge foundations.

Twenty-five thousand barrels of the cement were utilized in the construction of that splendid building which is to house the New York Stock Exchange. A fact for those who marvel at huge sums is that the company has made and sold upward of 20,000,000 barrels of cement. Dragon cement is a veritable dragon to decay and unreliable competitors.

TILE CLASSIFICATION WRONG.

Collector's Assessment as "Semi-Vitrified" Reversed by Appraiser.

Tiles imported by the American Shipping Company of Chicago were decided yesterday by General Appraiser McClelland to be dutiable at the rate of 4 cents per square foot dir[illegible]tly or by similitude as "tiles plain, [illegible] one color, e[illegible]ng two quare [illegible]ize." The[illegible]tor assessed [illegible]

CLIPPING FROM "JOURNAL OF COMMERCE," DEC. 20, 1901.

United States Custom House (Old Structure), New York City, Erected 1849.

United States Custom House, New York City, Completed 1908.

The Lawrence Cement Co. Sold Cement for Both the Old and New Custom House.

P. W. BARRICKLOW, PRES. AND TREAS. H. S. BARRICKLOW, VICE-PRES. W. H. PLANT, GENERAL MGR.

The Colonial Coal and Supply Company

MINERS AND SHIPPERS OF

COAL AND BUILDERS' SUPPLIES

BOTH PHONES 1009 BRUNSON BUILDING

COLUMBUS, OHIO. Nov. 10, 1908.

The Lawrence Cement Co. of Penn'a.,
Philadelphia, Pa.

Gentlemen:-

We have handled the Dragon-Portland cement for the past year and desire to continue handling it for the coming season. We have found it superior in both color and strength to any of the other Portland cements we have ever handled. The great features that we find takes with our people are that each and every car is uniform and exactly the same as the last one and that the cement does not vary in color or strength as a great many of the Eastern cements.

Yours very truly,

The Colonial Coal & Supply Co.

W H Plant Mgr

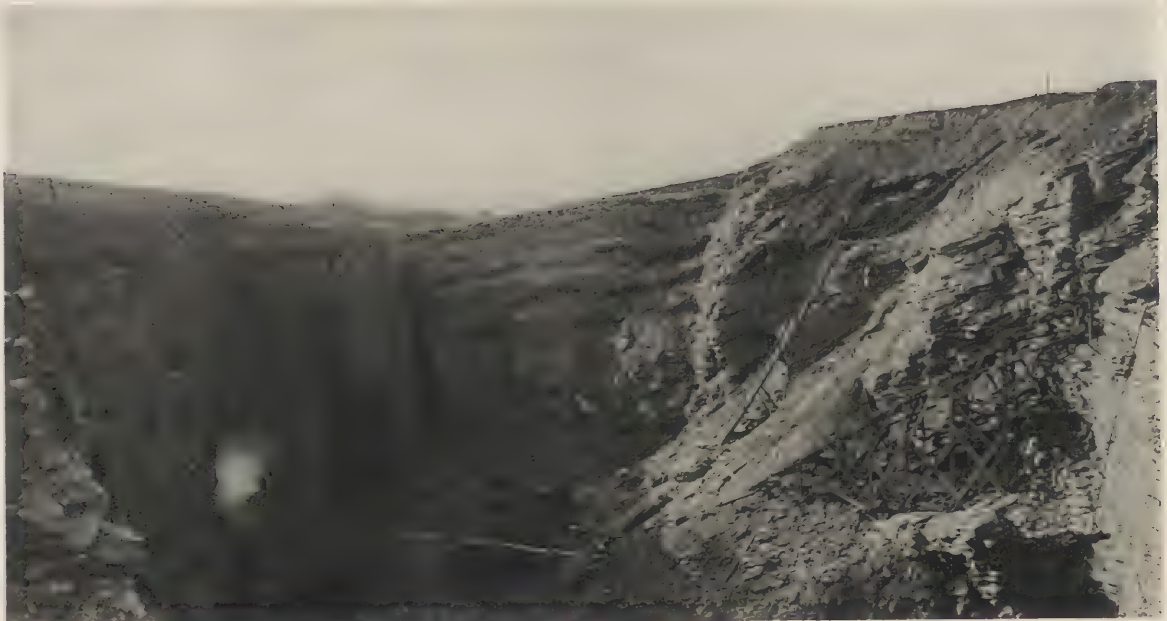
Cement Raw Materials.

The raw materials from which so-called Portland Cements are manufactured must consist essentially of calcium carbonate and silicate of alumina. The exact proportions required are determined by the actual chemical composition of the materials combined, since each of the ingredients as found in nature, or as a result of some process of manufacture, includes a certain proportion of the other principal ingredient, together with various foreign materials which are not essential in the manufacture of cement. The usual ratio is about 75% carbonate to 25% silicate. These two substances are obtainable in so many diverse forms that a large range of choice of raw materials is possible. The following combinations have actually been used in different cement manufacturing plants in various parts of the United States:

Cement rock and limestone.
Limestone and clay.
Limestone and shale.
Marl and clay.
Chalk and clay.
Limestone and blast furnace slag.
Alkali waste and clay.

Cement rock occurs in various parts of the United States. It is really an argillaceous limestone, or one which contains both argillaceous matter (silicate of alumina, or clay) and lime. It is usually rather soft in texture and occasional deposits are found which, when properly treated, will produce a perfect Portland Cement without admixture of any other special rock.

The deposit in the Lehigh Valley is one of the largest and purest in the world, and the quarry of the Lawrence Portland



Cement Stone Quarry of Lawrence Portland Cement Co.

Cement Company, situated as it is in Northampton County, is most fortunately located for the securing of a very high grade rock. Many other manufacturers operate several separate mills, taking rock quarried from entirely different sites, but the miscellaneous result of such diverse origin and manufacture is sold as a single brand. The Lawrence Portland Cement Company operates quarries at one point only, the whole face of which is thrown down by each blasting operation. These conditions, together with the uniformity of the rock disclosed by the chemical analyses given on page 14, show the wonderful uniformity of the crude material employed in the manufacture of "DRAGON" Portland Cement. When it is appreciated that this highly uniform crude stock is manufactured in a single immense mill, one cause of the superiority of "DRAGON" Portland Cement is evident.

Certain drawbacks are inherent in the use of other materials than cement rock and limestone in the manufacture of Portland cement. For instance, the employment of slag is apt to produce a cement which will disintegrate in the air, which can therefore be used only where great strength and hardness are not required; naturally, too, there is apt to be an excess of sulphur and other detrimental ingredients. A small amount of cement has been produced from the waste obtained from the manufacture of soda when the ammonia-soda process is employed. This waste is essentially a precipitated chalk and when burned with clay will produce a Portland cement of a certain quality.

Weldon F. Weston
WHOLESALE AND RETAIL DEALER IN
HAY, FEED, GRAIN, COAL,
MASONS MATERIALS. FLAGGING, COPING AND STEPS.
171 MAIN ST AND LONG WHARF

Fishkill Landing, N.Y. March 15, 1907

The Lawrence Cement Co.,

New York City.

Dear Sirs:-

I have been selling your "Dragon" Portland Cement almost exclusively for five years or more and have done so with entire satisfaction to my customers and to myself. It has been uniform, has worked in such a manner as to be desired by the trade generally, and I do not hesitate to recommend it to the public for any purpose whatever.

Yours very truly,

Weldon F. Weston

The Uniformity of Quality of "Dragon" Portland Cement.

Every effort is made throughout the manufacture of "Dragon" Portland Cement to produce an article of absolute uniformity in every point and the tests herewith submitted prove conclusively that through a period covering a number of years, "Dragon" Portland cement has been found as uniform as it is possible to make such an article.

The uniformity of any given cement depends upon eight elements:

(a) Uniformity in the chemical composition of the cement rock and of the limestone.
(b) Uniformity of mixture of the raw materials.
(c) Intimateness of the mechanical mixture of the cement rock and of the limestone.
(d) Uniformity of the degree of fusion of the clinker.
(e) Uniformity of fineness of grinding.
(f) Uniform quality and quantity of set regulator.
(g) Uniformity of seasoning.
(h) Absolute exclusion of dampness.

The materials used must be such as are provided by nature and any company is fortunate in possessing quarries where a uniform quality of rock exists. That the LAWRENCE PORTLAND CEMENT COMPANY is thus fortunate is shown by the following chemical tests of the cement rock removed during a short period of two months operation in each of the years 1906, 1907 and 1908.

DATE.	$Si\,O_2$	$Fe_2\,O_3+Al_2\,O_3$	$Ca\,Co_3$	$Mg\,Co_3$
Nov. & Dec. 1906	15.80	8.08	70.03	5.11
" " 1907	15.82	8.21	69.83	5.25
" " 1908	15.41	8.20	70.30	5.23

United States Senate Office Building, Washington, D. C.
"Dragon" Portland Cement Used Exclusively.

The limestone employed by this company has not varied in composition as much as 1½% in carbonate of lime during the same period, thus proving the high character of the materials employed in the manufacture of "Dragon" Portland Cement.

This uniformity of composition is made more perfect by the number of times the materials are handled between the time stone is taken from the quarry until it is ready for the kilns. Each such operation tends to distribute small inequalities throughout the whole mass so that the greater the number of such mixings the more uniform is the quality of the final output. By carrying on blasting operations so that the face of the full width of the quarry is blasted down at one time, the stone receives its first mixing. This stone is further mixed when the quarry cars are dumped at the tipple into the large hopper bottom cars running to the crushers. Each crushing operation mixes the particles so that when it is known that fully *eleven* such manipulations take place before the ground mixture is burned it will be evident to what extent uniformity of the raw material is assured. Chemical analyses are made of each bin of cement rock and limestone before the stone is used. The mixing of the limestone with the cement rock is carefully done at the scales which are set by the chemist as a result of his determinations. After this mixture has been made it is subjected to analyses every two hours and any necessary corrections are made prior to final grinding.

Doubtless the most important item in the manufacturing of cement in regard to its uniformity is that of the burning of the clinker. The crude mix must be uniformly fine and the air blast and composition of coal must be uniform. The coal employed by the Lawrence Portland Cement Company during the last eight years has been so uniform in quality that its ash content has not varied 3% during that long period, so that the degree of heat and its rate of change from point to point are absolutely alike from hour to hour and day to day.

The gypsum rock used for the purpose of regulating the set is carefully analyzed to detect any inequalities in chemical com-

DRAGON PORTLAND CEMENT

Bin No. E15 to A16 to A17 — 1 P. M., Aug. 25, 1908. 8 P. M., Aug. 25, 1908.

Composition		CEMENT									
	Fineness	FINENESS		WATER		SETTING TIME		STRAIN		BOILING
Hour	No. 100	No. 100	No. 200	Percent	Temp.	Initial	Final	1 day	7 days	
1 A. M.	93+	95	78	20+	66	180	400	510	785	Good
2 "	93	95+		21	67	205			885	"
3 "	92	94		"	68	185			850	"
4 "	92+	95+	78	"	69	185	370	475	815	"
5 "	92	94+		"	70	175			815	"
6 "	92	95		"	60	195			715	"
7 "	94+	94+	77	"	61	175	390	460	820	"
8 "	94	93+		"	62	205			825	"
9 "	93+	94		"	65	195			820	"
10 "	94+	94+	77	"	68	190	360	490	880	"
11 "	93+	94+		"	68	160			830	"
12 "	93+	96		"	63	160			870	"
1 P. M.	95	95+	77+	"	63	160	360	425	770	"
2 "	92	96+		"	65	170			810	"
3 "	93	96+		"	66	170			830	"
4 "	92	95	77	"	68	165	355	475	780	"
5 "	93	96		"	69	190			875	"
6 "	90	93+		"	70	170			855	"
7 "	93	96	79	"	69	160	360	445	830	"
8 "	90+	95		"	64	170			860	"
9 "	92+	93+		"	64	170			885	"
10 "	92	93+	76+	"	63	170	390	470	785	"
11 "	92	95		"	64	180			825	"
12 "	92+	95		"	66	185			800	"

position and the addition is made before the clinker receives its first crushing. The fineness of grinding is tested hourly, often each machine in the plant being separately investigated. In addition to these tests for fineness, the cement is tested hourly in accordance with the specifications of the American Society of Civil Engineers and a much more rigid accelerated test than that required by the society is carried out. Cement pats are first steamed for three hours and then boiled for an equal period, thus making certain the quality of the final product.

The tests reported in the table on the opposite page were taken at random from one day's result and show the uniformity of the tests obtained even though two individuals conducted the tests at different hours of the day.

The table on page 21 shows the uniformity of the average results obtained for a single month from year to year during the past four years and clearly indicates the remarkable uniformity of " Dragon " Portland Cement.

No experiments have been devised to determine the color variations but the fact that cement users throughout the country have remarked on the uniformity of color of Dragon cement is the best indication of uniformity of its quality. (See testimonials pages 10, 22, 92, 98 and 106.)

This uniformity of quality is the most important item to be considered with regard to any cement when the quality itself is within required limits. A standard of quality has been established within a certain range of values by an agreement entered into between the manufacturers of Portland cement and large numbers of users, such as the American Railway Engineering and Maintenance of Way Association, the American Institute of Architects, the American Society of Testing Materials, the National Association of Cement Users, etc.

Specifications as to this standard of quality have been prepared by the American Society for Testing Materials, while a standard method of making the tests required to determine the quality have been drawn up by the American Society of Civil Engineers.

L. & D. EDWARDS & CO.,
DEALERS IN
ALL KINDS OF BUILDING MATERIALS,
COAL AND KINDLING WOOD.
LONG BRANCH, NEW JERSEY.

July 30, 1901

F. E. Morse Co.,

17 State St, N. Y.

Gentlemen:-

We can recommend the "Dragon" Portland cement for every purpose that Portland cement is used. An artificial stone bulkhead was built with it at this place and it is the only cement that ever remained in tact one year after being used.

We have sold it for concreting and widewalks, which have resulted satisfactory in every respect.

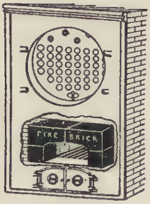
Yours truly,

L & D Edwards & Co

TABLE OF AVERAGE TESTS OF "DRAGON" PORTLAND CEMENT.

MONTH OF JULY.	24 HOURS. NEAT	7 DAYS. NEAT	28 DAYS. NEAT	7 DAYS. 1:3 SAND	28 DAYS. 1:3 SAND
1905	462	731	799	269	359
1906	486	737	805	253	331
1907	514	700	809	257	327
1908	506	726	804	280	351

NOTE—These are the average of the tests made during the single month of July for the years shown, and demonstrate beyond cavil the wonderful uniformity of "Dragon" Portland Cement from year to year.



TRADE MARK

PRESBREY FIRE BRICK WORKS

B. C. PEIRCE, TREAS.

212 SOMERSET AVE.

TAUNTON, MASSACHUSETTS, U. S. A.

ALL AGREEMENTS ARE CONTINGENT UPON STRIKES, DELAYS OF CARRIERS AND OTHER CAUSES UNAVOIDABLE OR BEYOND OUR CONTROL.
QUOTATIONS SUBJECT TO CHANGE WITHOUT NOTICE

Taunton, Mass., Oct 8,1908.

Mr. Charles D. Stout, Gen'l Sales Agent,
Lawrence Cement Company,
1 Broadway, New York City

Dear Sir:-

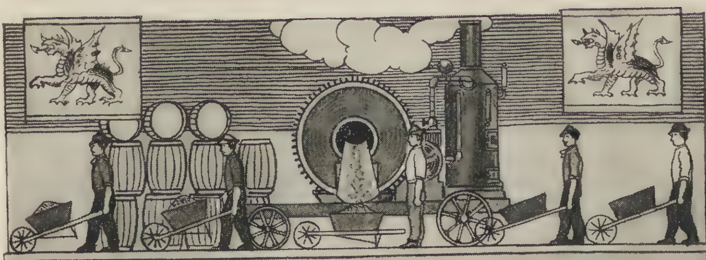
In reply to your favor of the 18th ulto, relative to the matter of furnishing a customer with "Dragon" cement for the manufacture of cement blocks, would say that our Mr. Goff called upon the party in question yesterday. He had made up blocks from several different Portland cements, which were still in drying stage.

The blocks made from the sample barrel of "Dragon" which we furnished him for trial seem to come out a better color, that is more like granite than the other two kinds tried. Furthermore, the "Dragon" blocks appeared to be the hardest of the three.

Think undoubtedly we shall under these circumstances land the business, but nevertheless we are going to accept your offer to send to Taunton the man of experience referred to so that he can give our party the benefit of his experience in getting started. Will advise you later on, probably in a week, just what date will be most convenient, giving you amply time in which to make proper arrangements.

Yours very truly,

PRESBREY STOVE LINING CO.
By B C Peirce Treas
G



Standard Specifications—

FOR CEMENT

Adopted August 15th, 1908, by the

AMERICAN SOCIETY FOR TESTING MATERIALS.

GENERAL OBSERVATIONS.

1. These remarks have been prepared with a view of pointing out the pertinent features of the various requirements and the precautions to be observed in the interpretation of the results of the tests.

2. The Committee would suggest that the acceptance or rejection under these specifications be based on tests made by an experienced person having the proper means for making the tests.

SPECIFIC GRAVITY.

3. Specific gravity is useful in detecting adulteration. The results of tests of specific gravity are not necessarily conclusive as an indication of the quality of a cement, but when in combination with the results of other tests may afford valuable indications.

FINENESS.

4. The sieves should be kept thoroughly dry.

TIME OF SETTING.

5. Great care should be exercised to maintain the test pieces under as uniform conditions as possible. A sudden change or wide range of temperature in the room in which the tests are made, a very dry or humid atmosphere, and other irregularities, vitally affect the rate of setting.

National House of Representatives Office Building, Washington, D. C.
"Dragon" Portland Cement Used Exclusively.

Tensile Strength.

6. Each consumer must fix the minimum requirements for tensile strength to suit his own conditions. They shall, however, be within the limits stated.

Constancy of Volume.

7. The tests for constancy of volume are divided into two classes, the first normal, the second accelerated. The latter should be regarded as a precautionary test only, and not infallible. So many conditions enter into the making and interpreting of it that it should be used with extreme care.

8. In making the pats the greatest care should be exercised to avoid initial strains due to molding or to too rapid drying-out during the first twenty-four hours. The pats should be preserved under the most uniform conditions possible, and rapid changes of temperature should be avoided.

9. The failure to meet the requirements of the accelerated tests need not be sufficient cause for rejection. The cement may, however, be held for twenty-eight days, and a retest made at the end of that period using a new sample. Failure to meet the requirements at this time should be considered sufficient cause for rejection, although in the present state of our knowledge it cannot be said that such failure necessarily indicates unsoundness, nor can the cement be considered entirely satisfactory simply because it passes the tests.

SPECIFICATIONS.

General Conditions.

1. All cement shall be inspected.

2. Cement may be inspected either at the place of manufacture or on the work.

3. In order to allow ample time for inspecting and testing, the cement should be stored in a suitable weather-tight building having the floor properly blocked or raised from the ground.

4. The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment.

5. Every facility shall be provided by the contractor and a period of at least twelve days allowed for the inspection and necessary tests.

MANUFACTURER OF THE CELEBRATED
"KING WINDSOR DRY MORTAR."

Telephone Main 25

D. J. PENNEY

DEALER IN

HARD AND SOFT COAL

Sewer Pipe and Fittings, Lime, Cement
Plaster, Fire Brick and Clay

OFFICE:
Cor. Nickel Plate and Broadway

Lorain, O., Nov. 2, 1908. *190*

Mr. Hurst,
Cleveland Macadam Co.,
Cleveland, O.

Dear Sir:-

In the past year in the city of Norwalk, O., I used 1500 bbls. of your Dragon Cement in the construction of a 60" concrete sewer, a mixture of 1-3-5.

We had a test made at Mansfield, O. of several cements and the Dragon had the best test of all the cements tested and in our sewer it gave us the best job of any cement we ever used. We could pull our forms in twelve hours and when we had occasion to cut a hole in the sewer it was almost impossible to get it through.

If I ever have an occasion to use cement again, nothing but Dragon for mine.

Thanking you for prompt attention to orders and shipment of same and further stating the Dragon is the best cement I have ever used in my past eight years of handling cement, I beg to remain

Yours very truly,

G. C. Penney

6. Cement shall be delivered in suitable packages with the brand and name of manufacturer plainly marked thereon.

7. A bag of cement shall contain 94 pounds of cement net. Each barrel of Portland cement shall contain 4 bags, and each barrel of natural cement shall contain 3 bags of the above net weight.

8. Cement failing to meet the seven-day requirements may be held awaiting the results of the twenty-eight day tests before rejection.

9. All tests shall be made in accordance with the methods proposed by the Committee on Uniform Tests of Cement of the American Society of Civil Engineers, presented to the Society, January 21, 1903, and amended January 20, 1904, and January 15, 1908, with all subsequent amendments thereto.

Portland Cement.

17. Definition. This term is applied to the finely pulverized product resulting from the calcination to incipient fusion of an intimate mixture of properly proportioned argillaceous and calareous materials, and to which no addition greater than 3% has been made subsequent to calcination.

18. The specific gravity of the cement, ignited at a low red heat, shall not be less than 3.10, and the cement shall not show a loss on ignition of more than 4%.

Fineness.

19. It shall leave by weight a residue of not more than 8% on the No. 100, and not more than 25% on the No. 200 sieve.

Time of Setting.

20. It shall not develop initial set in less than thirty minutes, and must develop hard set in not less than one hour, nor more than ten hours.

Tensile Strength.

21. The minimum requirements for tensile strength for briquettes one inch square in section shall be within the follow-

ing limits, and shall show no retrogression in strength within the periods specified.*

Age.	*Neat Cement.*	*Strength.*
24	hours in moist air	150-200 lbs.
7	days (1 day in moist air, 6 days in water)	450-550 "
28	days (1 day in moist air, 27 days in water)	550-650 "
	One Part Cement, Three Parts Standard Sand.	
7	days (1 day in moist air, 6 days in water)	150-200 lbs.
28	days (1 day in moist air, 27 days in water)	200-300 "

If the minimum strength is not specified, the mean of the above values shall be taken as the minimum strength required.

Constancy of Volume.

22. Pats of neat cement about three inches in diameter, one-half inch thick at center, and tapering to a thin edge, shall be kept in moist air for a period of twenty-four hours.

(a) A pat is then kept in air at normal temperature and observed at intervals for at least 28 days.

(b) Another pat is kept in water maintained as near 70° F. as practicable, and observed at intervals for at least 28 days.

(c) A third pat is exposed in any convenient way in an atmosphere of steam, above boiling water, in a loosely closed vessel for five hours.

23. These pats, to satisfactorily pass the requirements, shall remain firm and hard and show no signs of distortion, checking, cracking or disintegrating.

Sulphuric Acid and Magnesia.

24. The cement shall not contain more than 1.75% of anhydrous sulphuric acid ($S\,O_3$) nor more than 4% of magnesia ($Mg\,O$).

The normal chemical composition of Portland Cement is usually within the following limits:

Silica	20.00 to 25%
Alumina	5.00 to 9%
Oxide of Iron	2.00 to 5%
Lime	57.00 to 65%
Magnesia	1.00 to 4%
Sulphuric Acid	0.25 to 2%

* (For example, the minimum requirement for the twenty-four hour neat cement test should be some specified value within the limits of 150 and 200 pounds, and so on for each period stated.)

ABSTRACT OF SPECIFICATIONS OF PORTLAND CEMENT OF VARIOUS COUNTRIES.

American Standard.

TIME OF SETTING	FINENESS	SOUNDNESS OR CONSTANCY OF VOLUME	SPEC. GRAVITY	TENSILE STRENGTH
Initial set not less than 30 minutes; hard set not less than one nor more than ten hours.	Residue of not more than 8% on No. 100 sieve and not more than 25% on No 200 sieve.	Pats of neat cement about 3 in. diameter ½ in. thick at center tapering to fine edges, kept in moist atmosphere for 24 hours. Such pats kept in air at normal temperature for 28 days, and in water at 70° F. for same period to remain firm and hard and show no cracking or disintegration. Similar pat in an atmosphere of steam above boiling water for 5 hours to show no cracking or disintegration.	When thoroughly dried at 212° F. to be not less than 3.10.	Briquettes 1 sq. in. in section to stand as follows: NEAT CEMENT. 24 hours in moist air............175 lbs. 7 days (1 in air, 6 in water)....500 lbs. 28 days (1 in air, 27 in water)...600 lbs. One part Cement, 3 parts Standard Sand. 7 days (1 in moist air, 6 in water) ....150 lbs. 28 days (1 in moist air, 27 in water) ....200 lbs.

English Standard.

TIME OF SETTING	FINENESS	SOUNDNESS OR CONSTANCY OF VOLUME	SPEC. GRAVITY	TENSILE STRENGTH
Final set not less than 2 hours nor more than 7 hours.	Residue of not more than 18% on 180 mesh sieve and not more than 3% on 76 mesh sieve.	Expansion as shown by the Le Chatelier apparatus 10 mm. if cement has been aerated for 24 hours, 5 mm. if cement has been aerated for 7 days.	Not less than 3.15 when fresh, or 3.10 after 28 days from grinding.	Briquettes 1 sq. in. section to stand not less than the following stresses: NEAT CEMENT. 7 days (1 in moist air, 6 in water) ....400 lbs. 28 days (1 in moist air, 27 in water) ....500 lbs. The increase from 7 to 28 days shall be at least— 25% when 7 day test is between 400 and 450 lbs. 20% when 7 day test is between 450 and 500 lbs. 15% when 7 day test is between 500 and 550 lbs. 10% when 7 day test is between 550 and 600 lbs. 5% when 7 day test is 600 lbs. or upwards. One part Cement to 3 parts Standard Sand. 7 days (1 in moist air, 6 in water) ....150 lbs. 28 days (1 in moist air, 27 in water) ....250 lbs. Increase between 7 and 28 days to be at least 20%.

French Standard. (*For use in sea water.*)

Time of Setting	Fineness	Soundness or Constancy of Volume	Spec. Gravity	Tensile Strength
Initial set shall not take place within 20 minutes and permanent set within 3 hours but must be complete within 12 hours.	Not more than 40% should be retained on a sieve having 4900 meshes per sq. cm. or more than 2% on one having 324 meshes per sq. cm.	Specimens are to be kept in moist air for 24 hours and then some immersed in sea water and others in water maintained at 100° C. for three hours. The points of the Le Chatlier apparatus must not change more than 5 mm. in the boiling test.		The tensile strength shall be at least 20 kg. per sq. cm. After twenty-four hours in moist air the cement is to be placed in sea water and must develop a tensile strength of at least 15 kg. per sq. cm., at the end of 7 days and at the end of 28 days, 30 kg. per sq. cm. There must be at least 2 kg. increase between the 7 and 28 day tests. Mortar specimens must develop 6 and 11 kg. per sq. cm. respectively.

French Standard. (*For use near sea water.*)

Time of Setting	Fineness	Soundness or Constancy of Volume	Spec. Gravity	Tensile Strength
Initial set shall have taken place within 6 hours and permanent set must be complete at the end of 30 hours.	Not more than 5% should be retained on a sieve having 900 meshes per sq. cm. or more than 2% on one having 324 meshes per sq. cm.	Specimens are to be kept in moist air for 48 hours and then some immersed in sea water and others in water maintained at 100° C. for three hours. The points of the Le Chatlier apparatus must not change more than 5 mm. in the boiling test.		After 24 hours in moist air and thereafter in sea water, mortar specimens must develop a tensile strength of at least 3 kg. per sq. cm. at the end of 7 days and 6 kg. per sq. cm. at the end of 28 days. There must be at least 2 kg. per sq. cm. increase between the 7 and 28 day tests.

French Standard. (*For use far from sea water.*)

TIME OF SETTING	FINENESS	SOUNDNESS OR CONSTANCY OF VOLUME	SPEC. GRAVITY	TENSILE STRENGTH
Initial set shall not take place in 8 minutes nor permanent set in less than 2 hours; but permanent set must be complete within 12 hours.	Not more than 30% should be retained on a sieve having 4900 meshes per sq. cm. or more than 10% on one having 900 meshes per sq. cm.	Specimens are to be kept in moist air for 24 hours and then some immersed in fresh water and others in water maintained at 100° C. for three hours. The points of the Le Chatlier apparatus must not change more than 10 mm. in the boiling test.		Slow setting and average cement mixed 1 part cement and 3 parts standard sand: *Compressive Strength.* — *Tensile Strength.* 7 days .... 7 days, 12 kg. per sq. cm. 28 days, 180 kg. per sq. cm. — 28 days, 18 kg. per sq. cm. QUICK SETTING CEMENT. 7 days .... 7 days, 8 kg. per sq. cm. 28 days, 120 kg. per sq. cm. — 28 days, 12 kg. per sq. cm. The average of the best four of six specimens is to be taken. Briquettes 5 sq. cm. area and cubes 7 cm. on edge mixed 1 part cement to 3 parts standard sand, after submersion of 28 days in cold water or six days in warm water should develop stresses of 22 kg. per sq. cm. and 220 kg. per sq. cm. respectively.

German Standard.

TIME OF SETTING	FINENESS	SOUNDNESS OR CONSTANCY OF VOLUME	SPEC. GRAVITY	TENSILE STRENGTH
The initial set shall not take place in less than 1 hour.	Shall be such that not more than 5% is retained on a sieve of 900 meshes per square cm.	Cement shall be of constant volume as determined by a pat of neat cement on glass placed in water after 24 hours and showing no signs of curvature or cracking on the edge after a long time.		Shall develop with 1:3 standard sand, 160 kg. per sq. cm. compression on cubes of 50 sq. cm. surface, after 1 day hardening in air and 28 days in water. Tensile strength shall be at least 16 kg. per sq. cm. in test pieces at least 5 sq. cm. in area. Compressive strength of neat specimens shall be at least 200 kg. per sq. cm. after 1 day in air, 6 days in water and 21 days in air from 15 to 30° C.

Russian Standard.

TIME OF SETTING	FINENESS	SOUNDNESS OR CONSTANCY OF VOLUME	SPEC. GRAVITY	TENSILE STRENGTH
Initial set should not take place in less than ¼ hour or more than 1 hour from the moment the water is added and final set take place within 12 hours thereafter when tested according to the Austrian method.	Not more than 50% should be retained on a sieve containing 4900 meshes per sq. cm. and not more than 15% on one containing 900 meshes per sq. cm.	Pats in an atmosphere of steam for 1 hour should not show incipient disintegration nor should small pats reveal such troubles after 28 days in water.	Should not be less than 3.05.	Briquettes 5 sq. cm. in section should develop the following stresses: NEAT CEMENT. 7 days, 20 kg. per. sq. cm. 28 days, 25 kg. per sq. cm. 1 part Cement, 3 parts Standard Sand. 7 days, 7 kg. per sq. cm. 28 days, 10 kg. per sq. cm. The average strength of the four highest specimens in each case being accepted.

Austrian Standard.

Time of Setting	Fineness	Soundness or Constancy of Volume	Spec. Gravity	Tensile Strength
Portland cements are either quick average, or slow etting. Quick setting cements are those in which hardening begins within 10 minutes. Slow setting ones those in which hardening does not commence within 30 minutes. Between the quick and slow setting cements are the average ones. Tests are made with needle with an area of 1 sq. mm. supporting a weight of 300 G.	Not more than 30% should pass a sieve with 4900 meshes per sq. cm. and not more than 5% through one with 900 meshes.	Cement pats 10 cm. in diameter and 1 cm. thick in center after being kept moist for 24 hours are to be kept in an atmosphere of steam at 120° C. between 2 and 3 hours without cracking or disintegration. Similar pats after hardening in air for 24 hours are to be left in water for 27 days without effect.		After twenty-four hours in moist air the cement is to be placed in fresh water and must develop at least 25 kg. per sq. cm. at the end of 7 days and 35 kg. per sq. cm. at the end of 28 days. There must be at least 3 kg. increase between the 7 and 28 day tests. Mortar specimens must develop 8 and 15 kg. per sq. cm. respectively and show an increase of at least 2 kg. between the 7 and 28 day tests.

Swiss Standard.

TIME OF SETTING	FINENESS	SOUNDNESS OR CONSTANCY OF VOLUME	SPEC. GRAVITY	TENSILE STRENGTH
Cements in which the initial set takes place in 30 minutes are to be considered quick setting, while those in which the final does not take place within 3 hours are to be considered slow setting. Test is to be made with a weight of 300 G. supported on an area of 1 sq. mm.	Not more than 5% should be held by sieve having 900 meshes per sq. cm.	Pats 12 cm. in diameter, 1½ cm. thick should not be effected by being submerged for 24 hours in a bath of hot water or in water of ordinary temperature a period of at least 20 days. Specimens in the shape of spheres about 4 to 5 cm. in diameter should not crumble, crack or show other signs of disintegration after setting in water for 24 hours which is then gradually raised to a boiling point and maintained at that temperature for 3 hours.		

Fig. A.

Fig. B.

Fig. C.

Samples of Sand and Gravel.

R. G. SCOTT, JR. W. E. SCOTT J. P. SCOTT

Scott Brothers,

GENERAL CONTRACTORS

BARGE CANAL CONTRACT NO. 45

BELL TELEPHONE 212

BALDWINSVILLE, N. Y., Nov 16, 1908.

Mr. J. F. Miller, Sect.,
Cumberland Hyd. Cement & Mfg Co.,
Cumberland, Md.

Dear Sir:-

We are very glad indeed to testify as to the satisfactory quality of your cement, having recently finished a contract for the A. B. & A. R. R. Co. in Georgia, where we used some 25000 barrels of your cement, every car of which was subjected to a rigid test by the railroad company and not a barrel was rejected or held up for second test. On our Barge Canal work we have a contract with you for some 35000 barrels, having used about 8000 barrels, all of which was subjected to the tests of the State of New York, and so far we have not had the least trouble.

In the meantime we have used it on several small contracts with the above results.

Yours very truly,

SCOTT BROTHERS,

BY W. E. Scott

The Effect of Sand on Cement Mortar

Experiment shows that the character of the sand employed for making the mortar used for concrete blocks, sidewalks, brick masonry, stucco, reinforced concrete, etc., has a vital effect on the resulting product, so that a very careful study of all available sources of supply should always be made whenever a large structure is involved or a concern is undertaking the manufacture of cement products on any considerable scale. The strength of the mixture, its rate of set, and the yield obtainable with a given quantity of cement are all found to depend on the nature of the sand employed and very often perfectly good cement has been wrongfully condemned because of trouble which has ultimately been traced to the sand with which the cement was mixed.

Extensive experiments have been carried out under the direction of the U. S. Geological Survey and the results obtained are exceedingly instructive if from no other standpoint than the one that few absolutely definite conclusions can be drawn from them. Twenty-two samples of sand, twelve samples of gravel screenings, and twenty-five samples of stone screenings were carefully analyzed physically, and numerous mortar specimens prepared with a single special cement, the specimens being tested after varying periods. Over 25,000 individual tests were made in this connection and while certain broad generalizations, like those which follow, can be deduced, the most instructive points are brought out from study and comparison of individual specimens.

Mortar made of each variety of material was tested with each proportion of cement selected, viz.: 1:3 and 1:4 in tension, compression and bending, respectively, at ages of 7, 28, 90, 180 and 360 days. In general it was found that greater uniformity existed between the results obtained after 180 days than in those made after shorter periods, because unavoidable differences in the cement were more apparent at younger ages, while such irregularities disappeared as the test pieces became older.

Each sample of sand, gravel and stone screening, was separated into sizes by passing through sieves of the commercial sizes called 10, 20, 30, 40, 50, 80, 100 and 200. The results showing the quantities thus obtained were plotted and analyzed in various ways. The results seemed to indicate that the nearer the grading curve approached a uniform grade line from the finest to the coarsest, the greater was the strength of the mortar obtained.

The voids were also determined in each specimen and the strength, in a general way, was found to decrease with an increase of voids.

The density of the mortar made from each specimen was accurately determined and in a very general way it was observed that high density usually meant greater strength and greater weight per cubic foot, and vice versa. The yield of each mortar with a given mixture and quantity of the crude materials was also carefully measured.

The general opinion, hitherto widely held, was also confirmed that mortars mixed with coarse materials are stronger than when the materials may be considered as very fine.

Examination of the numerous photographs and comparison with the tests of the samples illustrated show that so-called "sharpness" of grain has apparently nothing to do with the strength of the mortar produced.

A certain amount of so-called silt or pure clay when added to mortar has often been found to increase its strength until a point is reached where this addition exceeds about ten per cent of the cement, after which it becomes an increasing detriment. The Government tests do not throw definite light on this point.

But particular interest attends the making of particular comparisons, a few of which are as follows:

The two samples of gravel screenings of Figure A and Figure B, p. 36, are apparently almost identical. One was secured in Michigan and one in Ohio. One tested 8567 pounds per square inch in compression while the other tested only 4650 under similar conditions. Judging from the appearance of the photograph, the sample of sand on the same page (Fig. C) would be taken to be of excellent quality, while it developed only 3677 pounds. Again, compare the two sands shown on page 40 (Figure D and Figure E). One tested 4225 and the other 7554 when mixed 1:3 while the better sand tested 5193 when mixed 1:4, thus showing itself far superior to even the first mentioned sand when mixed with 33% less cement. Several other

Fig. D.

Fig. E.

Samples of Sand.

pairs of samples almost identical in distribution of sizes, tested 2000 pounds apart, showing that that feature is not a predominant one. All samples which would provide sufficient material, had one single size of grain separated, and all samples thus obtained were similarly tested. Only that material which would pass a number 30 sieve and be held by a number 40 was used, mixed 1:3 in each case. The results ran from about 3600 lbs. to about 2000 lbs. among twenty samples of sand; thus disclosing a very wide variation in *quality* entirely aside from all questions of size of grain or amount of cement used.

Finally the "yield" or amount of mortar obtainable when cement and sand are mixed in specified proportions, and the strength of the resulting mixture are interesting points to all who must purchase large quantities of sand.

In the Government tests, sand and gravel screenings gave much higher yields than did stone screenings, as a general rule.

The actual yield of mortar in proportion to the quantity of sand used (by weight) varied from 1.27 down to 1.02. Obviously a purchaser could afford to pay much more for the first kind mentioned than for the second, and when it might simultaneously be found possible to secure high strength tests with good yields, a still more advantageous condition would result. A yield of 1.18 may be considered much above the average, but one sample showing that yield tested 3677 lbs. while three others yielding 1.21, 1.19 and 1.20 gave results of 6125, 6719 and 7108 lbs. respectively. Of 58 samples the average yield was 1.13, so that it is evidently possible by a proper selection of sand to secure from 5 to 10% above the average amount of mortar to be expected and still mix the sand and cement always in the same relative proportions.

A cement user should therefore examine and test most carefully all possible sources of sand supply so as to secure the best result and on the other hand should never condemn a cement unless similar careful tests have been made to determine the effect of the sand being used. For purposes of comparison, a special sand has been selected by scientists and called the "Standard Sand." It may be obtained from all large testing laboratories and many cement manufacturers. Results obtained with it, however, are usually much below those obtainable with commercial sands, the Government result being 4042 pounds per square inch in compression, which is seen to compare only fairly with most of the other examples mentioned.

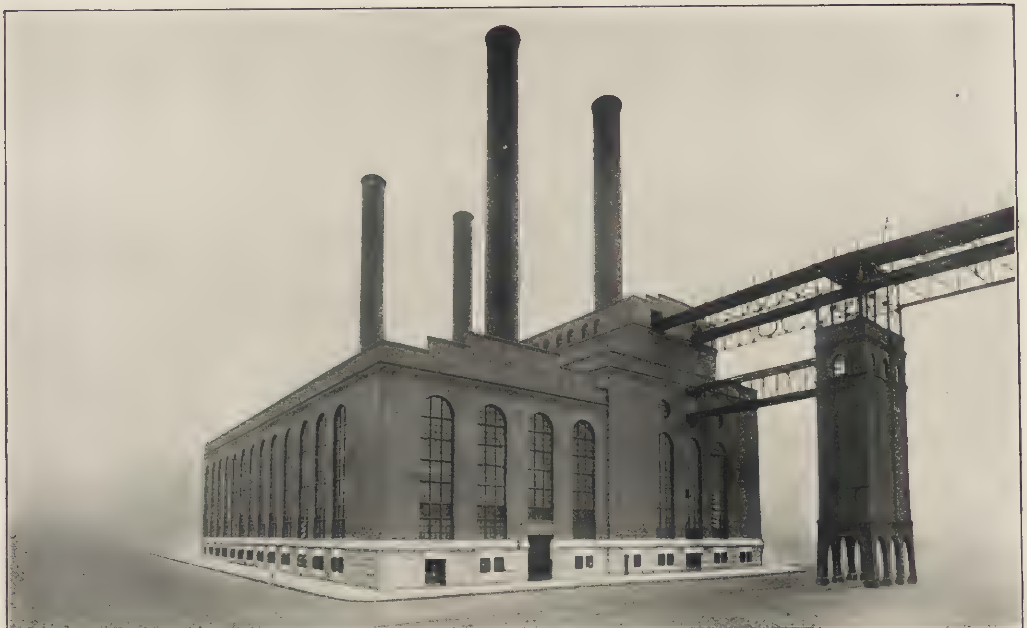
HIGH SCHOOL, FAIRHAVEN, MASS.
"DRAGON" PORTLAND CEMENT USED EXCLUSIVELY.

Finishing Concrete Surfaces

In all super-structural concrete work, a certain degree of artistic treatment is involved. This very largely takes the form of panels, mouldings, projections, pilasters, belt courses, balconies, etc., but surface finish also must be considered in all but the simplest structure.

The uniformity and dullness of untreated concrete surfaces is not pleasing to most persons, so that many architects and constructors make use of variations in color, as well as of special surface treatment. The wet concrete, which is now most often employed, is so very plastic that it shows in the minutest detail the peculiarities of the moulds in which it is formed. Necessarily, therefore, imperfections in these moulds are to be carefully avoided and only such moulds selected as will give surfaces which are pleasing in appearance. Forms which are imperfectly constructed with different thicknesses of lumber used indiscriminately or with dirt or old cement adhering to their surfaces, will not produce results which are compatible with ordinary conditions. Where it becomes necessary to secure perfect surfaces as they leave the forms, the latter should be constructed of narrow, matched lumber, at least one inch and a quarter thick, carefully braced so as to prevent bulging, and thoroughly washed with water immediately before fresh concrete is deposited. Joints should be carefully filled with clay and the grain marks can be reduced to some extent by oiling the lumber and then throwing fine sand against the oiled surface. With careful construction, very elaborate mouldings, intaglio work, etc., can be produced, but such work is costly, since the carpentry must be equal to the best cabinet work or pattern making. Very beautiful results, however, can be obtained where cost is not an item.

With this form of treatment, the surface is always extremely smooth and unless treated in color, is apt to be somewhat monotonous. Many people admire a rougher texture. Several



Pennsylvania Railroad Company's Power Plant,
Long Island City, N. Y.
"Dragon" Portland Cement Used Exclusively.

methods are employed in securing such results. Sand blasting is very effective, and if carefully done by an expert, can be made to produce panels, belts, etc., and the effect of the blast can be carried as deeply as desired. By a slight cutting of the surface, the appearance of sandstone is obtained. Deeper cutting will remove more of the mortar which has been flushed against the forms and the aggregate will be exposed.

By a proper selection of the various ingredients entering into the original mixture, variations in surface and even in color are obtainable, if the surface is sand blasted or otherwise treated, so as to reveal these aggregates. Broken brick, white marble chips, blue trap rock, other colored marbles, etc., together with the gray matrix of the cement mortar, can be combined, to give almost any desired combination of colors and surface effects. White pebbles of various sizes can be employed and the aggregate may be anything from the size of coarse sand to that of pieces an inch or more in diameter. Obviously, if special effects are desired with this course of treatment the concrete must be deposited with exceptional care.

Instead of sand blasting, the concrete surface may be scrubbed with water and ordinary scrub brushes, if the concrete is not allowed to get too old and hard. Water should be freely used from a hose and the amount of force exerted in the scrubbing will give shallow or deep cutting effects as desired. For this work only from twenty-four to forty-eight hours should elapse between the time the fresh concrete is deposited and that when its surface is treated, depending on the weather conditions. Older concrete may be similarly treated by etching with acid. This may be either sulphuric, hydrochloric or acetic. The concrete work should be deposited in a fairly dry mixture if acid is eventually to be used. The acid should finally be neutralized with an alkaline solution and well soaked with water. (This acid treatment is covered by patents.)

Less vigorous treatment can be secured by wetting and rubbing the surface with a block of hard wood, old concrete, sandstone or carborundum; or scrubbing with a stiff wire brush; but in each instance the concrete must not have attained too great an age. A vigorous use of water is also advisable. Other textures of surface may be obtained by tooling with pneumatic tools or by

hand. The concrete should be very hard for this method of handling (at least forty-five days old), and when care has been taken with the forms and in the placing of this concrete, effects practically identical with those of natural stone can be procured. Bush-hammering is the most popular method, while other forms of finish have also been employed. All the exterior surfaces of the Connecticut Avenue Bridge in Washington, were thus treated. (See description elsewhere.) Unless form lumber which is uniform in thickness is employed, it becomes necessary to tool some parts of the surface deeper than others. This variable depth of tooling produces differences in the surface which are objectionable, so that care should be exercised in the construction of the forms in regard to this point, although they may be constructed of rough lumber if more convenient.

The use of rough lumber and a very dry mixture carefully rammed will also give a pleasing surface under certain circumstances.

Almost any special variety of treatment and of any degree of intricacy can be secured by the use of stucco. Obviously the stucco may be of any color, texture and finish. But it must be firmly bonded to the backing and very carefully applied. Smooth finished stucco work is apt to develop fine hair cracks and is consequently objectionable. These cracks are also usually discovered in other varieties of surfaces, but with slap-dash and pebble-dash work they are not noticeable. Some workmen allow the stucco to become partially set and re-temper it in an endeavor to obviate this surface "crazing," as it is called. Mouldings and heavy work of other kinds must be built up little by little, each layer carefully applied and fully hardened before the next one is installed. About 25% of lime mortar can advantageously be mixed with the cement mortar for stucco work.

It is much easier to produce color effects by employment of stucco than by endeavoring to employ colored cement or some coloring compound in the mortar of the mass concrete work. Either for stucco or mass work, however, the following materials have been successfully employed:

Buff Stone Color: Use 36 parts Portland cement, 8 parts by weight of yellow oxide of iron, and 1 part red oxide.

Red: Use 87 parts Portland cement, 11 parts red oxide of iron, 2 parts black oxide of iron or copper.

Yellow: Use 84 parts Portland cement, 14 parts yellow oxide of iron, 2 parts black oxide of iron or copper.

Caen Stone Color: Use 36 parts Portland cement, 4 parts yellow oxide of iron, ½ part red oxide.

Blue: Use 80 parts Portland cement, 18 parts azure blue or ultra marine, 2 parts black oxide of iron or copper.

Green: Use 85 parts Portland cement, 12 parts of oxide of chromium, 3 parts black oxide of iron or copper.

Chocolate: Use 88 parts Portland cement, 6 parts of black oxide of manganese, 4 parts red oxide of iron, 2 parts black oxide of iron or copper.

Black: Use 87 parts Portland cement, 13 parts black oxide of manganese or any carbon black.

White: Use 67 parts Portland cement, 33 parts sulphite of barytes.

Only those coloring materials should be employed which consist of the oxides of the various elements, since the salts are all liable to disintegration. Even colors thus obtained appear to fade to some extent in the course of years. In mixing the ingredients, the greatest care and exactitude are essential. If improperly mixed, the surfaces are apt to be spotty. In deciding upon a tint, specimen containing different proportions of the coloring matter and of Portland cement should be made and allowed to become quite dry before observation.

More satisfactory methods of securing color are by the employment of brick or tile embedded in the concrete surface. Very striking effects can be secured by the use of red brick in the form of quoins, lintels, belt courses, etc., in combination with concrete for the pilasters, sill courses, etc. Occasionally, curtain walls under windows, etc., are constructed in red or buff brick with good effect. If the brick are to be embedded in the mass concrete work as the latter is carried on, a rather dry mixture should be used, and in order to maintain the exact positions of the several pieces, joints should be maintained by the use of wooden wedges and strips. Tile, either glazed or unglazed, and of any degree of intricacy of design as to shape and color, can be employed. They may be first glued to perforated forms with common bill posters' paste, and then the mass concrete deposited as usual. When the concrete is properly set, deluging the forms

Woodbridge Glen Dam, Woodbridge, Conn.
(Erected by the New Haven Water Company.)
"Dragon" Portland Cement Used Exclusively.

with water will dissolve the paste so as to allow the removal of the moulds. Such tile work can also be cast in the shape of slabs which are to be set in recesses moulded in the mass concrete work, if this method is found more economical than placing the tile on the moulds for the original surface. When the latter course is employed, copper tacks are sometimes used to secure the tile to the centering, no discoloration from rust taking place with the lapse of time where copper has been used. Mosaic floors, the soffits of arches and domes, belt courses around columns or along facades, ornamental medallions and innumerable other points have been beautifully ornamented by this means. In a sense, one becomes a painter using clay paint. The breadth of design, width of line, etc., must obviously be proportioned to the distance of the observer from the ornament.

Bronze, copper or painted pressed metal, can also be employed to any extent required to give color and ornamental effect to concrete work. Light iron grilles, balconies, etc., are very effective in combination with concrete work, but all metal when so used must be absolutely prevented from corroding, or otherwise the concrete surface will be stained so as to become immediately very unsightly. Blocks of mortar or concrete made with very fine aggregate, can be planed, sawed, or turned with machines just as the softer quarried stones are handled.

RINEHART & DENNIS COMPANY
RAILWAY CONTRACTORS
COLORADO BUILDING
WASHINGTON, D. C.

W. F. DENNIS, PRESIDENT
W. R. RINEHART, VICE PRESIDENT
HOLLIS RINEHART, GEN. MGR.

TELEPHONE, MAIN 4472

November 18, 1908.

Cumberland Hydraulic Cement & Mfg Co.,

Cumberland, Md.

Gentlemen:-

Replying to your favor of the 14th inst., beg to say we have used a large quantity of your Dragon Portland cement in connection with the lining of two double track tunnels on the Baltimore & Ohio Railroad near Alberton, Md., also on other works, and the cement has always given entire satisfaction.

Yours truly,

RINEHART & DENNIS COMPANY.

Water Proofing of Concrete

Except for mass concrete foundations, all work should be made as water proof as possible. Experiment has shown that rich concrete is practically impervious to water. Mixtures poorer than one to four are apt to be very pervious. Concrete made with large aggregate is much more impervious than that containing only smaller sizes. Two-and-a-half inch stone, for instance, is far superior to three-quarter inch. Gravel is superior to broken stone in producing imperviousness. Again, the thicker the wall the less water will flow through it in proportion, and the older the concrete the less pervious it is. Usually, after the flow of water has continued for a few hours, it is found to diminish rapidly in quantity, apparently due to the filling of the pores with the very fine particles carried in suspension by the water. If this action takes place at all, it is produced very rapidly. On the other hand, if it is not thus rapidly produced, the effect of the water is apt to be injurious, because it and the chemicals it contains will dissolve certain parts of the concrete which will then be carried away and the whole mass become honey-combed, even to the point of failure. The denser the concrete, the less pervious it is; so that the usual line along which experimenters work, is to find means and materials for filling the minute pores which form in the concrete as it hardens. As has been said, extra cement will do this. Hydrate of lime is an exceedingly impalpable material and is often employed. Pure silica or alumina in the form of silt or clay is also effective to a certain extent and when such clay happens to have the property of slightly swelling when damp, the imperviousness is supposed to be increased.

Certain chemicals are also sometimes added to the cement or

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H. C. MASTERS, PRES. W. J. GRANGER, VICE-PRES. C. F. MULLEN, SEC'Y & TREAS

The Masters & Mullen Construction Co.

MEMBER BUILDERS EXCHANGE

Reinforced Concrete and Fireproofing

CONCRETE BUILDINGS, FOUNDATIONS, WALKS
FLOORS, PAVEMENTS, BRIDGES

452-4 ROSE BUILDING
Cleveland, O.

Nov 12th, 1908

Re to "Dragon" Cement.

The Cleveland Macadam Co.,
Builders Exchange.

Gentlemen:-

One of the jobs in course of construction at this time on which we are using "Dragon" Cement is the Plain Dealer Building.

The interior construction of this building is composed of steel columns in concrete, and reinforced concrete girders, supporting rather exceptionally long span floor slabs. These spans run up as high as twenty-six feet, and carry loadings from three hundred to four hundred pounds per square foot. The thickness of these slabs varies from twelve inches to sixteen inches, and is composed of hollow tile and reinforced concrete.

This particular construction of long span slab work is very advantageous to the owner of the building, as the reduction in head room due to beams and girders is cut down to a minimum.

The concrete of this building is composed of "Dragon" cement and crushed furnace slag, and reinforced with cold twisted steel bars.

This work, as you know, is being done under the supervision of Mr. George H. Smith, Architect, of this City.

Yours very truly,

THE MASTERS & MULLEN CONST. CO.

Per

C. F. Mullen

Sec'y & Treas.

the mortar. Some of them are entirely inert and simply act as registers of flow because they produce in connection with water a capillary phenomena of a negative variety, similar to that which exists between mercury and glass or between oil and water. Others are supposed to form insoluble precipitates as soon as extra water is encountered, these precipitates filling the voids as does the silt or extra cement above described.

Moisture is prevented from getting below the surface of a concrete structure in many cases by special treatment of that surface. Long continued trowelling will produce a dense condition such as is found in a sidewalk, which is practically impervious to water.

Numerous waterproof paints have been devised but very few of them are effective for long periods because the majority contain oils of some nature which are attacked by the alkali in the cement with the production of soluble soaps. These are washed away with every rainstorm and the surface soon becomes non-waterproof. Pure paraffine wax installed with the application of heat is doubtless the most effective method of preventing ingress of moisture.

All methods of surface treatment have the disadvantage that they prevent further hardening of the concrete as soon as they are installed, because no more moisture can penetrate to the interior and it is moisture which is essential to further hardening.

ALL AGREEMENTS CONTINGENT UPON STRIKES, ACCIDENTS OR OTHER CAUSES BEYOND OUR CONTROL.

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BOSTON. NEW YORK. PHILADELPHIA. BALTIMORE. WASHINGTON, D. C. CHICAGO. BUFFALO. ST. LOUIS. SAN FRANCISCO. TORONTO, CAN. LONDON, ENG. PARIS, FRANCE. BRUSSELS, BELGIUM. DORTMUND, GERMANY. BALE, SWITZERLAND VIENNA, AUSTRIA.

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ELEVATOR, LIGHT AND VENT SHAFTS.
FIREPROOFING COLUMNS, GIRDERS AND BEAMS
ATTACHING EXPANDED METAL
TO IRON AND WOOD CONSTRUCTIONS.
FIREPROOF DWELLINGS.

THE EXPANDED METAL FIREPROOFING CO. OF PITTSBURG,

303 HOME TRUST BUILDING,

541 WOOD STREET.

CAPITAL, $200,000 00.

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S. GARRISON, President.
D. H. LITTELL, Vice Pres.
W. J. McMARLIN, Sec'y & Treas.

PITTSBURG, PA. June 7,06.

Cumberland Hydraulic Cement & Mnfg Co.,
Cumberland, Md.

Gentlemen:-

In reply to your recent letter to the writer, will say that our delay in answering is due to my absence from the City.

The buildings which we have built of strictly reinforced construction in which your Dragon cement was used was the Charleston National Bank Building, Charleston, W. Va., and the Samuel Ach Building, Cincinnati, Ohio, also the Salvation Army Barracks, Cincinnati, Ohio.

We have used your Dragon cement in probably fifty buildings with structural steel frames and reinforced concrete floor, all to our entire satisfaction.

Respectfully yours,

EXPANDED METAL FIREPROOFING CO.,

W. J. McMarlin

Sec'y & Treas.

Prevention of Rust in Reinforcement for Concrete.

Two theories exist with regard to the action which takes place when iron or steel corrodes. One is that this action is electrolytic in nature, while the other considers that the reaction is purely chemical. In either case, moisture is essential, while with regard to the purely chemical theory, an excess of oxygen or other oxidizing agent is required.

Pure cement, with its slight alkaline reaction, when applied in a continuous coating over the surface of a steel or iron rod or other shape, has been found to act as a preservative of high order. Paints are actively exploited, which contain as the principal ingredient, Portland Cement either as manufactured for usual purposes or produced synthetically with this particular object in view. In every instance it is obvious that an absolutely continuous film of cement must be applied to the steel surface. In reinforced concrete work, this is secured by properly proportioning the concrete mixture so that the cement and water forms a grout which can be worked against the reinforcement rods, and if properly done, will coat them in the required manner. With this in view a slight excess of water is required, and it is necessary that in the case of floor slabs, beams and girders, the mortar from the concrete be constantly made to flow ahead of the majority of the material being deposited, so as to surround the reinforcement and thoroughly coat it. This action is largely facilitated by a gentle tapping of the reinforcement which produces a slight vibration. This acts so as to keep the larger particles of the concrete pushed away from the surface of the reinforcement, the space between being filled with the mortar, consisting largely of cement.

Some practitioners have required that all reinforcement be dipped in a bath of cement grout before being installed in the forms, but, by careful manipulation during the deposit of the concrete, this extra handling and cost is unnecessary and can be obviated. Where special care has not been taken, however, reinforcing rods have been uncovered after a few years and found nothing but a streak of rust.

In the case of cement work which is applied under the trowel, such as stucco, etc., or where the reinforcement is in such a shape that it cannot be manipulated so as to secure the complete coating of its surface with grout, it becomes necessary because of the per-

viousness of such stucco or concrete to the action of air and water, to supply other methods of preventing the rusting of the reinforcement. Where heavy steel beams are used as grillages, for instance, or in the floor systems of composite bridges, subways, etc., it is very essential that rust be prevented and that stray electric currents are not allowed to attack the metal structure. Various coatings have been devised, some of which are claimed to be of high resisting power against moisture and electricity, and many experiments have been performed to discover their real virtues. A high grade of asphalt or coal tar pitch, when uniformly applied to a thoroughly cleaned structure which is not so cold that the pitch hardens so rapidly as to become brittle, has been found particularly effective.

In the case of stucco, greater trouble has been experienced, and many instances are known in which large areas have become separated from the original structure because of complete corrosion of the metal reinforcement, resulting in much unsightliness and some absolute danger. Here again, special coatings for the metal work have been employed. Proprietary compounds, to be added to the cement in a dry state or to the cement mortar in the form of a liquid, are also widely advertised. They are supposed to make the stucco waterproof and hence prevent the possibility of rust in the metal work on which the stucco is placed. Finally, exterior coatings over the surface of the finished work are often applied. Doubtless the most perfect of these is wax which is driven into the cement work under heat and remains as a perfect preventive of any action by moisture, acid or alkali, so long as the stucco does not crack and allow entrance of some destructive agent through capillary action. Were it possible to use the pure cement directly against and completely covering the wire lath or other metal work on which the stucco is placed, the necessity of these other devices above mentioned would be obviated, but a stucco mixed rich enough to produce this effect would be too costly under ordinary circumstances, and resort can better be made to other methods for economic reasons.

In general, the preventing of rust on steel imbedded in cement mortar and concrete, can be obviated where dense masses are produced and where the metal work can be completely coated with a rich cement mixture. Where this condition has been found to exist, reinforcement has been known to remain in a condition as perfect as when it left the rolling mills, even after severe exposure of the concrete work to destructive agencies for long periods extending over as many as fifteen or twenty years.

Storage of Cement

The usual methods of shipment of cement are as follows:

Cotton Sacks: Cotton sacks in which "Dragon" Portland Cement is shipped bear the fac-simile of the "Dragon" label and the sack is of the best quality, securely tied. Each sack of cement weighs 95 pounds.

Paper Bags: Paper bags bear the fac-simile of the "Dragon" label and the quality of the paper is of the best, making a strong package for those desiring cement shipped in paper. Each bag of cement weighs 95 pounds.

Barrels: The barrels are made of first grade staves, selected heading and patent hoops, making an especially strong, neat package. Barrels are well lined with water-proof paper. The "Dragon" label is pasted on one end of every barrel and the brand is stencilled on the opposite end and in three places on side of barrel. Every barrel of "Dragon" Portland cement weighs 400 lbs. gross. Wherever cement is stored, it must be kept absolutely dry. Moisture from the ground and from condensation is to be as carefully avoided as from rain and snow.

Storehouses erected with their floors about three feet above the ground are found convenient for purposes of shipment either by truck or by rail and at the same time they effectively prevent trouble from ground moisture. If the floors are constructed of concrete or of plank laid directly upon the ground, before putting in any cement 2 x 4 scantling should be first laid down about 30 inches apart and then inch-and-a-half or two-inch plank laid upon them to form an air space under the pile of cement bags or barrels.

Steel frame structures covered with galvanized iron and even

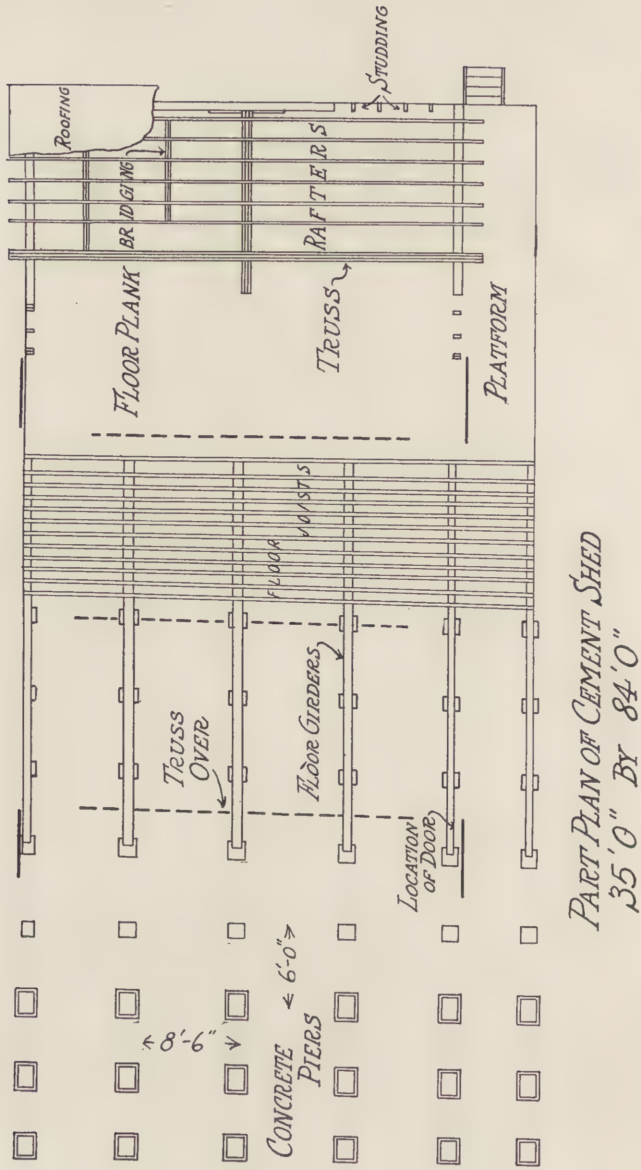

ROOFING
STUDDING
BRIDGING
RAFTERS
FLOOR PLANK
TRUSS
PLATFORM
FLOOR JOISTS
TRUSS OVER
FLOOR GIRDERS
LOCATION OF DOOR
8'-6"
6'-0"
CONCRETE PIERS
PART PLAN OF CEMENT SHED
35'0" BY 84'0"

FIGURE I.

brick walls often drip with condensation from the atmosphere, so that timber is far superior for shed purposes wherever its erection is permissible according to municipal building and fire department regulations. Cement in sacks can seldom be stored to advantage to heights greater than that of twenty or twenty-two full bags. Barrels can be tiered more than an equivalent height but if carried too high, require special hoisting arrangements or long inclines and the barrels are apt to burst. The tiering of cement in bags higher than ten requires extra labor in and out. Cement in paper bags is not easy to handle because the bags are apt to break through the middle.

In piling bag cement it is wisest to separate each shipment and preferably each car load. The latter is the practice followed by many large users. Cars contain from 135 to 200 barrels. A 200 barrel car consists of 800 bags. If piled 10 high, 800 bags can conveniently be arranged in 5 rows of 16 bags each. Five times the length of a bag is approximately 9 feet. Sixteen times the width of a bag is approximately 20 feet. These figures require very snug piling. If bags are piled 20 high, a somewhat greater length is necessary because the end bags must be arranged in the form of a "bulkhead" to resist the outward pressure. Such a bulkhead can best be made by laying a first row of headers, carried ten high with the bags behind placed as usual. The eleventh and succeeding tiers should also have an end row of headers, but they should overlap only about half the length of a bag of the lower ten tiers, extending over the first one of the cross rows. In the upper section the header row should be carried only eight high, and instead of seven rows of bags, only six should be used. The inside portion between the two end bulkheads should be made long enough to take 14 bags. With this arrangement, a pile will contain four bags less than 1600 or two cars of 800 each. Each bulkhead should therefore have two extra bags placed on top and each will then consist of 170 bags. Each interior vertical row across the pile will consist of 90 bags. The upper ten layers will contain 660 bags, and the lower section 940 bags. In the smaller pile, each tier parallel with the end of the pile contains 50 bags and it is a very easy matter to tally piles and keep track of shipments. With the higher piles the arithmetic is more complicated. A pile 20 bags high will measure very close to ten feet to the top.

It will be found best to maintain a gangway about six feet wide wherever cement has to be handled, but only about two feet

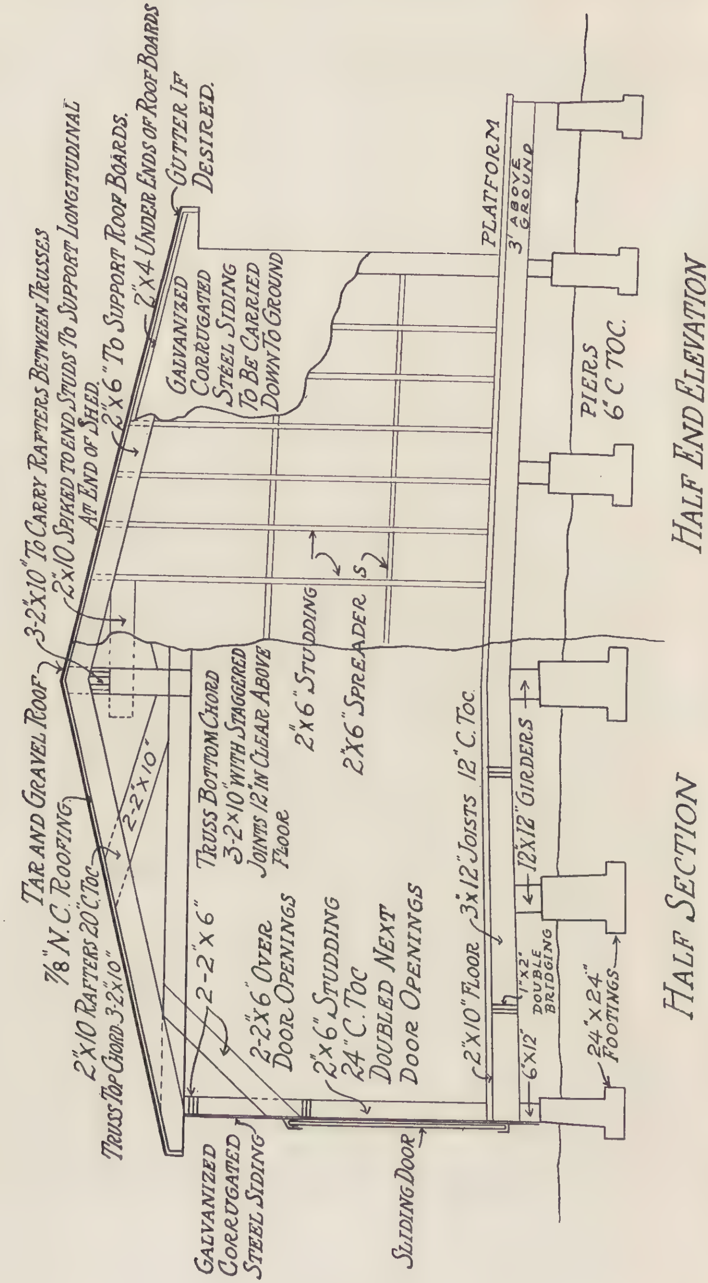

TAR AND GRAVEL ROOF
7/8" N.C. ROOFING
2"X10 RAFTERS 20"C.TOC
TRUSS TOP CHORD 3-2"X10"
3-2"X10" TO CARRY RAFTERS BETWEEN TRUSSES
2"X10 SPIKED TO END STUDS TO SUPPORT LONGITUDINAL
AT END OF SHED.
2"X6" TO SUPPORT ROOF BOARDS.
2"X4 UNDER ENDS OF ROOF BOARDS
GUTTER IF DESIRED.
2-2"X10"
TRUSS BOTTOM CHORD 3-2"X10" WITH STAGGERED JOINTS 12" IN CLEAR ABOVE FLOOR
2-2"X6"
2-2"X6 OVER DOOR OPENINGS
2"X6" STUDDING 24" C.TOC DOUBLED NEXT DOOR OPENINGS
2"X6" STUDDING
2"X6" SPREADER
S
GALVANIZED CORRUGATED STEEL SIDING TO BE CARRIED DOWN TO GROUND
PLATFORM
3' ABOVE GROUND
3"X12" JOISTS 12" C.TOC
2"X10" FLOOR
1"X2" DOUBLE BRIDGING
6"X12
12"X12" GIRDERS
24"X24" FOOTINGS
PIERS 6' C TOC.
HALF SECTION
HALF END ELEVATION
GALVANIZED CORRUGATED STEEL SIDING
SLIDING DOOR

FIGURE 2.

is enough to allow between piles, just sufficient for a tally man to make his way through.

In storing barrels, the end one on the bottom layer is placed against a "chock" firmly fastened to the floor. This chock should be a block of wood about six inches thick beveled on one side to fit against the bilge of the barrel. A barrel is about 20 inches in diameter so that a layer of any number of barrels will require 1 2-3 times as many feet in length. Conversely a length of any number of feet will house 3-5 times as many barrels. Each layer upward will contain one less barrel. The first layer will be about 20 inches high, two tiers will be about 36 inches high and each additional tier will add about 16 inches. Thus any number of tiers will be 1 1-3 times as many feet high plus 4 inches. Three tiers will be about 4 feet 4 inches. Six tiers will be about 8 feet 4 inches, and eight tiers will be 11 feet. This is about as high as it is well to carry such work. With long sheds provided with doors along the sides, with a railroad track along one side for instance, and a truck delivery platform along the other side, it will be found most convenient to arrange the piles of bags with their length parallel with the length of the shed, while piles of barrels can best go across the shed.

On the basis of the arrangement of bags described above, each pile will occupy a width of 11 feet. Consequently a shed should be of an over all width which is some multiple of eleven, plus about two feet. Thus it should be 24, 35 or 46 feet, etc., wide. This arrangement has the added advantage that doors are needed along the sides at intervals of 27 or 31 feet according as the piles are ten or twenty bags high. Thirty feet is thus seen to be a good unit length and the shed should be some multiple of this figure in length less about four feet saved at the ends. Trucks can be loaded so rapidly that a special loading platform is not usually necessary, although one about six feet wide will often be found convenient. Doors should be of the outside sliding variety, six feet wide by seven feet high. The roof can best be carried on girders or light trusses spanning the full width of the shed with a clear height of twelve feet above the floor. They can be supported on the walls, if of brick, or on posts, if the shed is of skeleton construction. Probably the most available style of structure is one consisting of a wooden frame covered on the sides with corrugated galvanized iron and with a flatly sloping roof covered with a high-grade tar, felt, and slag of gravel surface. The floor, if elevated above the ground should be designed for a total load of 900 lbs. per square foot. It should be

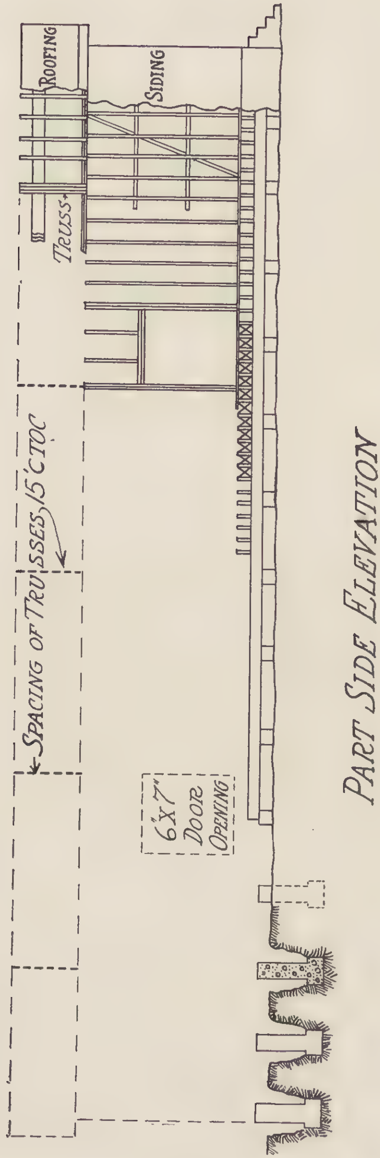

Roofing
Siding
Truss
Spacing of Trusses 15' C to C
6'x7' Door Opening
Part Side Elevation

Figure 3.

built with a slight slope and a platform, if used, should slope at least one-half inch per foot of width. Such a shed should be erected for about 40 cents per square foot, or often somewhat less. When the floor is not elevated above the ground the cost will be materially reduced.

The sketches on pages 58, 60, 62 and 64 give suggestions for a shed 35 feet wide and 80 feet long which will store 1800 barrels of cement in bags when piled ten high or twice that quantity if piled twenty high.

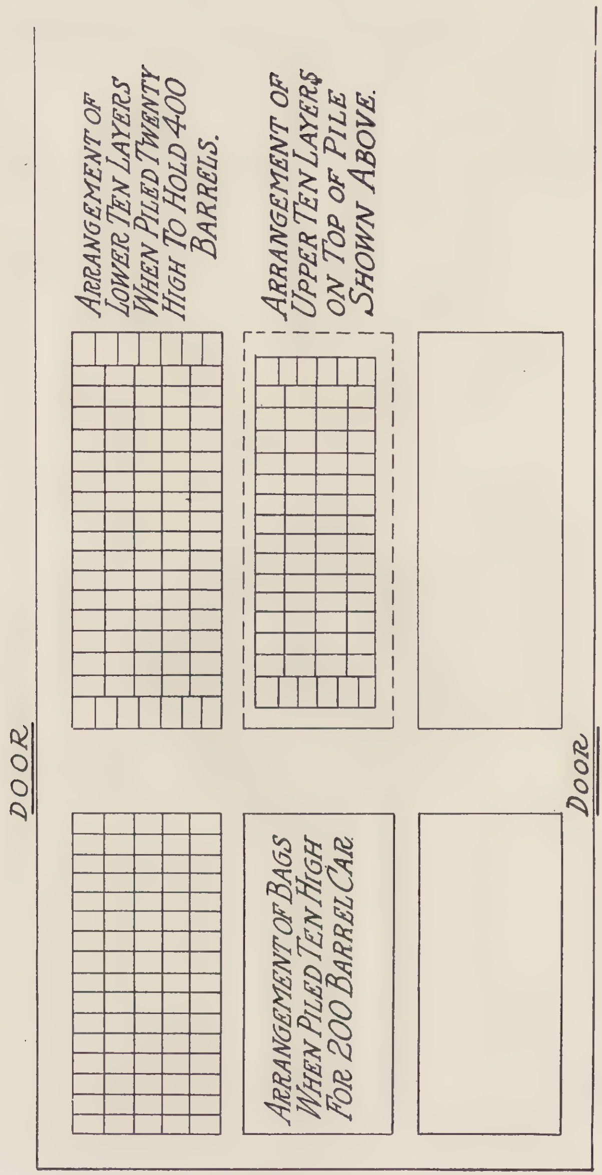

Arrangement of Lower Ten Layers When Piled Twenty High To Hold 400 Barrels.
Arrangement of Upper Ten Layers on Top of Pile Shown Above.
Door
Arrangement of Bags When Piled Ten High For 200 Barrel Car.
Door

Figure 4.

Specifications For Testing Cement Without Laboratory Equipment

The following specifications are suggested for the use of those who are such small users of cement or who have such small jobs as not to warrant the purchase of a special testing outfit, or the time and expense of sending samples to some testing laboratory for investigation. It must be understood that they are in large degree crude so that in the hands of inexperienced manipulators the results are to be interpreted only as a most general indication of the condition of the cement. However, in the hands of experienced cement testers, results can be obtained which only in rare instances need further checking.

The apparatus here described is purposely made of only the very cheapest and most easily obtainable nature. Obviously special testing apparatus is preferable in order to make possible proper methods of testing. The Lawrence Portland Cement Company holds itself ready to supply at actual cost any of the standard apparatus required to make cement tests.

Inspection. Upon receipt of a shipment see that the packages (either barrels or bags), are fully intact without breaks or tears. If a special brand has been specified see that all packages are of this make and that the cement in the several packages is the same in color, thus precluding the possibility of other brands having been substituted in the cover specified. If the specifications call for special sealing of bags, note the condition of such seals and whether or no they bear the inspector's mark. See that each shipment is stored by itself and properly labeled and that the storehouses are dry and are so maintained. Note whether cement is lumpy and whether these lumps can easily be crushed in the fingers. If not easily crushed the cement has probably been affected by dampness, but if easily crushed there is simply an indication of a seasoned cement.

Somerset Court House, Somerset, Pa.
"Dragon" Portland Cement Used Exclusively.

Sampling. Take as much cement as can be grasped by one hand from the open end of one bag out of each forty, or one bag from each truck load, if delivered in small lots. Also half empty the bag and take another sample from the center of the same bag. If cement is delivered in barrels, similarly sample each tenth package (unless a sampling iron is available or a three inch by twenty inch strip of heavy sheet iron from which one can be improvised). Thoroughly mix all samples from each lot (running them through a twenty mesh sieve if it is available).

Mixing. Secure a piece of glass about 18 inches square or larger (or a piece of sheet metal of similar size) and fix it on a bench or table. Secure a brick mason's trowel (8 inch), or devise a similar tool from a piece of stiff metal. (If these are not available a wooden spatula may be cut from a shingle or similar piece of wood.) Take as much cement as is held when even full in an ordinary drinking glass, spread on the glass in a ring and pour in the center a little water from another glass which has been previously graduated by scratching on the outside the successive depths to which small, equal (not necessarily known) quantities of water fill it. This rough graduation can be easily accomplished and should be carried so far as to ascertain the total number of the small quantities required to fill the glass level full. Turn the dry cement into the center of the ring containing the water until the water is all absorbed, after which work the mixture with the trowel or spatula by crushing it in small strips under the edge of the tool so held as to be nearly parallel with the glass, until the whole is of a uniform consistency. This operation should not take more than three minutes. Add water little by little, constantly working the mixture until the latter conforms to the conditions contained in the next paragraph. Note the amount of water as a decimal fraction (by volume) of the cement which is required to give the desired consistency. Multiply this fraction by 323 to secure the percentage of water by weight. The temperature of the mixing water and of the cement should be as near 70° F. (usual house temperature in winter) as possible.

If weighing scales are available use one-half pound cement instead of the quantity held by a drinking glass. (One-half pound is equivalent to 277 grams.)

Secure a piece of glass about 4″ square and mold upon it a cement pat of normal consistency about 3″ in diameter and ⅜″ thick. This should be kept in moist air, free from sudden

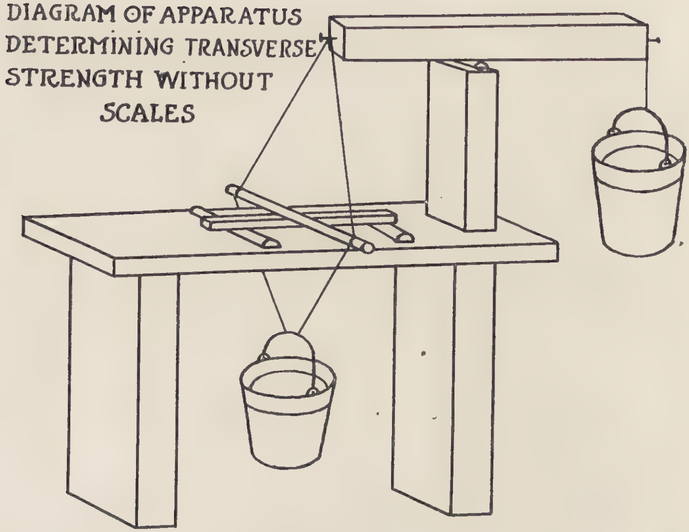


FIGURE 5.

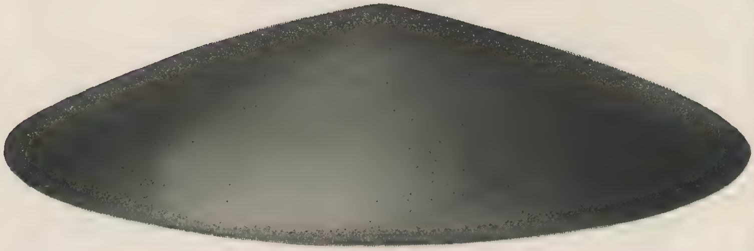


FIGURE 6.

PAT OF "DRAGON" CEMENT IN PERFECT CONDITION AFTER BOILING FIVE HOURS.

changes in temperature and draughts of air, and tested from time to time for setting or hardening.

If possible secure a cylindrical graduate marked in cu. cm. instead of graduating a glass tumbler as above described. When the graduate is used, note the number of cu. cm. of water required to secure the standard consistency. Since 1 cu. cm. of water of normal temperature weighs 1 gram, the percentage of water by weight required can be readily calculated. In any case it should be between 19 and 22%.

Normal Consistency. That amount of water is to be used in preparing test specimens which will produce a paste having the following characteristics:

1. It shall be firm, well bonded, shining and plastic.
2. It shall not change in consistency when worked double or triple periods of three minutes.
3. If dropped 20 inches from a metal trowel it shall leave the trowel clean, and a ball 2 inches in diameter shall fall without losing its diameter more than ¾ inch or cracking.
4. Light pressure should bring water to the surface and the paste should not stick to the hand.

Time of Setting. Secure a wire 1-12 inch in diameter (this is very close to 1¼ sixteenths of an inch and the head of a No. 2 pin has approximately this diameter. Or, the lead of a medium soft lead pencil can be stripped for a half inch from one end and made of the required size by the use of sand paper or equivalent). This wire or its equivalent should be fitted with proper weights so as to weigh 4 oz. adv. (A cylinder of neat cement mortar mixed to the consistency described above, one and one-eighth inch in diameter and 2⅜ inches long will be very close to the required weight. Such a cylinder can be easily moulded in a paper form rolled to the proper diameter, from a strip of paper of proper width.) Seceure another wire or equivlent, just one-half the diameter of the one above and weight it with one pound. (A cement cylinder two inches in diameter and three inches long will have this weight approximately.) The initial set is considered as having taken place when the first wire is just supported by the cement paste and the final set is considered as having taken place when the second one is similarly supported without appreciable indentation.

If possible a special set of Gillmore Needles should be secured and employed in testing.

Boiling Test. Secure some pieces of sheet glass about 4

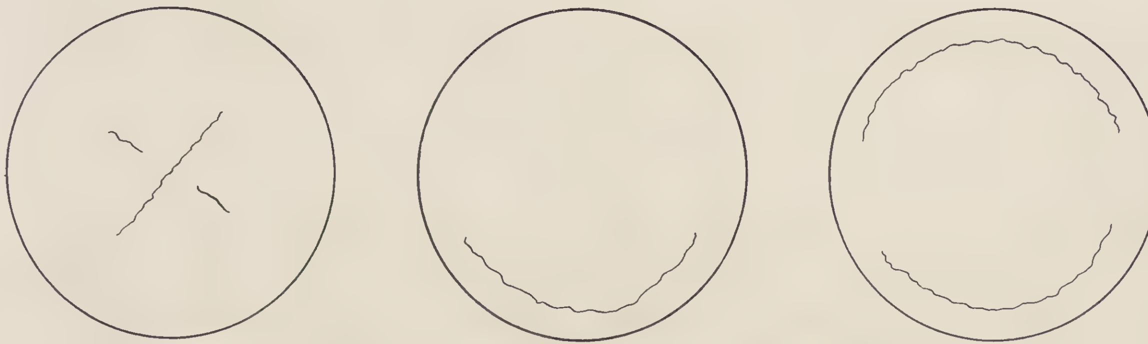


FIGURE 7. HARMLESS SHRINKAGE CRACKS

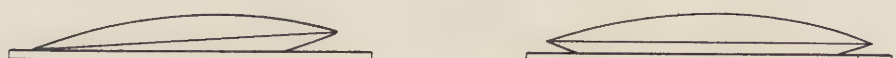


FIGURE 8. CONDITION DUE TO EXPANSION, (HARMLESS IN AIR PATS)

FIGURE 9. PATS WHICH HAVE LEFT GLASS

inches square (glass is essential), a metal pail at least six inches in inside diameter and some means of heating it so as to boil specimens in it for several hours at a time. The pail should be provided with a loose cover (a board will do, unless the source of heat is an open fire). Mould on the clean glass pieces three pats of paste of the consistency described above and form into a flat circular cone about 3 inches in diameter and one-half inch high at the center, with thin tapered edges. The glass pieces with their pats should be covered with a damp cloth (the latter not allowed to touch the cement) for 24 hours, after which one specimen should be placed in water as near 70° F. as possible for 28 days, being observed at intervals. Another glass with its pat should be left in the air at ordinary temperature for a similar period and also examined at intervals. A third specimen should be boiled for at least four hours, the water starting from its usual cool temperature. The glass should be supported above the bottom of the vessel on a wire support or on a few small pebbles or pieces of brick. To pass these tests satisfactorily, the pats should remain firm and hard, and show no signs of radical cracking around the edges, distortion or disintegration.

Figure 6 shows a pat which has satisfactorily passed the test.

Figure 7 shows shrinkage cracks. These are usually caused by the use of too wet a mixture or produced by too great rapidity of drying. Dry air will usually produce this effect so that such cracks indicate improper manipulation and not dangerous properties in the cement.

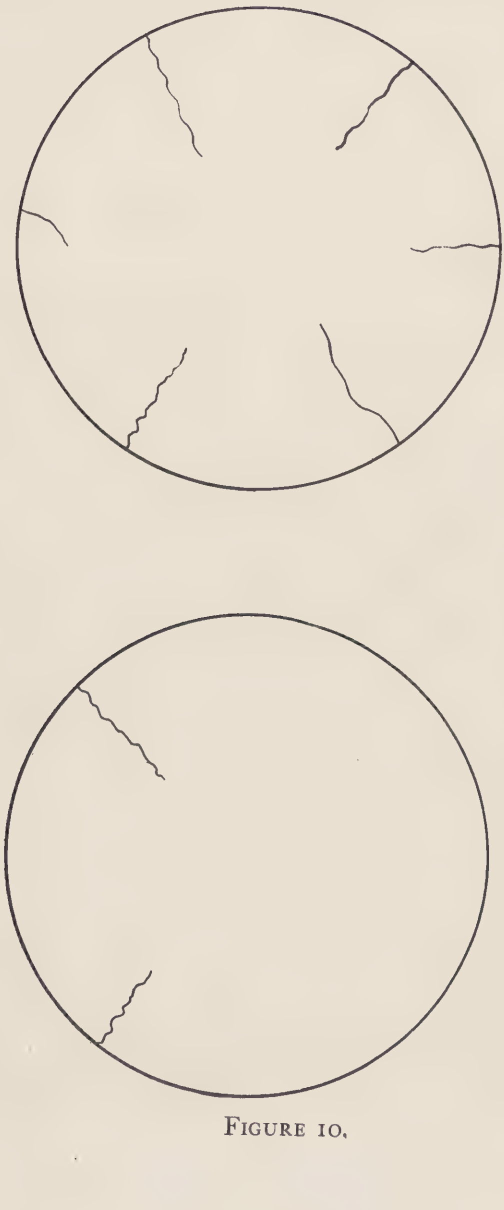
Figure 8 shows cracks caused by the curling of the edges of the cement away from the glass while the pat still adheres. This condition is common in air pats and is not dangerous unless extreme in character. It should not occur in water pats. If such cracks are found in water pats they denote the existence of qualities which should ordinarily condemn the sample.

If a pat is blotched, special investigation should be given to its cause, which may be either adulteration or under-burning.

Figure 9 shows pats which have left the glass because of deficient adhesion, contraction and expansion, respectively. The mere lack of adhesion in either air or water pats is not dangerous. A curvature greater than a quarter of an inch caused by expansion or contraction should be sufficient to condemn the sample.

Occasionally the glass will be cracked while the cement pat still adheres to it. This is not usually indicative of poor quality.

Figure 10 shows the radial cracks incident to incipient dis-



INCIPIENT DISINTEGRATION

FIGURE 10.

integration. Such cracks should always warrant rejection of the sample.

Figure 11 shows examples of complete disintegration which started as indicated in Figure 10.

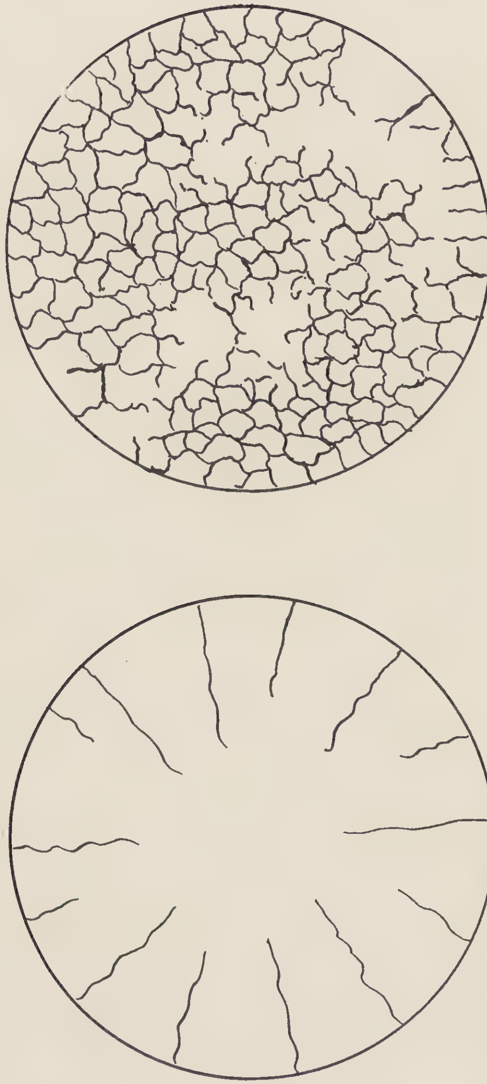
If pieces of glass are not available, balls of cement mixed to the consistency specified above may be substituted for the pats and similarly treated and observed.

If a sample fails in the boiling test it is safe to hold the shipment for at least 28 days and then make a second determination upon a fresh sample. If the second sample passes the test it indicates that the first sample needed seasoning. If the second test fails and the strength test is low the shipment should be considered as suspicious.

Novices should make at least a score of boiling tests before they should consider themselves competent to pass upon a sample of cement. It is also recommended that they secure some quick lime, powder it very finely and mix it in varying proportions with a sample of cement of tested high grade. These mixtures will develop some of the troubles described above and will give the beginner experience in recognizing cement of actual poor quality.

Strength by Transverse Test. Prepare prisms 1″x1″x 12″, by molding them in a carefully prepared form which can most readily be made by lightly tacking onto a flat board some narrow strips to separate the prisms, so arranged that the latter can be removed without danger of breaking. Mix the cement with the best sand available in proportions of 1:3, of the standard consistency and keep in moist air for 7 days or 28 days if possible. At the expiration of the desired period break the prisms by suspending a load from the center, first supporting the prism with a span of 10″ on semi-circular pieces of hardwood about 1″ in diameter. The load can be applied by means of water poured into a pail suspended so as to hang at the center of the prism and carefully counterbalanced so that only the weight of the water added comes upon the specimen, the dead weight of the pail being counterbalanced by means of some device similar to that shown in the diagram on page 68. The equivalent tensile strength of the cement can be taken as approximately ten times the center load required to break the prism on a 10″ span. The average of three prisms may be assumed as giving a value accurate within about 25%.

By arranging the apparatus as shown in the diagram, it is not necessary to weigh either the pail or the added weight since if



Complete Disintegration

Figure 11.

water is employed for the latter purpose its volume can be accurately determined and its weight computed at the rate of 62.3 pounds per cubic foot even more accurately than most small scales will register. The measurements may either be made in the pail itself or better by adding small quantities such as a part of a tumblerful which can be accurately computed.

Transverse strength tests are only approximate in nature and in no case should cement be condemned upon results obtained from them. If there are indications of lack of strength a special sample should be submitted to a regular testing laboratory for examination.

Troubles with Cement and their Usual Causes.

If a cement fails in a boiling test and is found to be very slow in setting it is probable that an excess of lime has been used or that the material has been imperfectly ground.

If a cement has a "flash set" or is extremely quick in this particular but hardens only very slowly, there is a probability that an excess of alumina is involved usually combined with overburning.

If a cement sets very quickly accompanied by heating during the mixing process and is found of low tensile strength, it is probable that an excess of clay has been used or that the cement is low in sulphuric acid (So_3).

TEST BUILDINGS JUST BEFORE STARTING TEST. FLOORS LOADED 150 LBS. PER SQUARE FOOT.
(*See Report on pp.* 81-89.)

Fire-Proof Qualities of Portland Cement Concrete

" Nearly one million dollars during every business day in the year, or an annual per capita tax of three dollars, represents the loss sustained by fire by the inhabitants of this country."

The above quotation is from an editorial in the *Cement Age* and the facts are susceptible of absolute proof. Nearly every magazine or newspaper of the country discusses this subject of fire prevention repeatedly, and the consensus of opinion is overwhelmingly tending toward the use of concrete. Both practical and laboratory tests have demonstrated beyond cavil its value as a great heat resisting medium. While certain clay products, like terra-cotta and brick, also resist heat to a high degree, still they possess certain other disadvantages for use in fire-proof floors, partitions, etc., which concrete when properly erected does not have. Well burned clay brick are fire retardents of the highest quality, but brick for floors, partitions or column fire-proofing is very heavy and therefore costly to use. Hollow terra cotta blocks have another disadvantage in that terra cotta possesses a relatively high co-efficient of expansion by heat so that the different parts of a terra cotta block, one side of which is exposed to heat, would expand differently, and fracture is apt to take place. This condition is clearly shown by innumerable photographs published with regard to the San Francisco fire, and, even better, by an experiment performed for the United States Structural Materials Laboratory at St. Louis. In each case the face of the terra cotta block which was exposed to the fire and water was almost entirely broken away. Concrete, similarly exposed and treated, was practically unaffected, the final result being simply a surface disintegration to a depth of perhaps half an inch. These conditions are clearly indicated in Figure 12, page 82.

The City of New York exacts a very rigid test from all contractors who desire to install any special type of fire-proof floor construction within its limits. The requirements are as follows:

FINAL LOAD OF 600 LBS. PER SQUARE FOOT ON WEST (3½") FLOOR. AFTER FIRE TEST.
(*See Report on pp.* 81-89.)

"In any .... construction and as a precedent condition to the same being used, tests shall be made as herein provided by the manufacturer thereof, under the direction and to the satisfaction of the Board of Buildings, and evidence of the same shall be kept on file in the Department of Buildings, showing the nature of the test and the result of the test. Such tests shall be made by constructing within inclosure walls a platform consisting of four rolled steel beams, ten inches deep, weighing each twenty-five pounds per lineal foot and placed four feet between the centres, and connected by transverse tie-rods, and with a clear span of fourteen feet for the two interior beams and with the two outer beams supported on the side walls throughout their length, and with both a filling between the said beams, and a fire-proof protection of the exposed parts of the beams of the system to be tested, constructed as in actual practice, with the quality of material ordinarily used in that system, and the ceiling plastered below, as in a finished job; such filling between the two interior beams being loaded with a distributed load of one hundred and fifty pounds per square foot of its area and all carried by such filling; and subjecting the platform so constructed to the continuous heat of a wood fire below, averaging not less than seventeen hundred degrees Fahrenheit for not less than four hours, during which time the platform shall have remained in such condition that no flame will have passed through the platform or any part of the same, and that no part of the load shall have fallen through, and that the beams shall have been protected from the heat to the extent that, after applying to the under side of the platform at the end of the heat test a stream of water directed against the bottom of the platform and discharged through a one and one-eighth inch nozzle, under sixty pounds' pressure for five minutes, and after flooding the top of the platform with water under low pressure, and then again applying the stream of water through the nozzle under the sixty pounds' pressure to the bottom of the platform for five minutes, and after a total load of six hundred pounds per square foot uniformly distributed over the middle bay shall have been applied and removed, after the platform shall have cooled, the maximum deflection of the interior beams shall not exceed two and one-half inches. Any system failing to meet the requirements of the test of heat, water and weight, as herein prescribed, shall be prohibited from use in any building hereafter erected.

" Concrete-steel construction will be approved only for buildings which are not required to be fire-proof by the Building

Applying Water on Test House, After the Fire. (*See Report on pp.* 81-89.)

Code, unless satisfactory fire and water tests shall have been made under the supervision of this Bureau. Such tests shall be made in accordance with the Regulations fixed by this Bureau, and conducted as nearly as practicable in the same manner as prescribed for fire-proof floor fillings......................
Each company offering a system of concrete-steel construction for fire-proof buildings must submit such construction to a fire and water test."

In at least one actual test, conducted under the direction of Professor Woolson, of Columbia University, "DRAGON" Portland Cement successfully passed these exacting requirements of the New York Building Department. The result of this test is contained in the following report and the effects produced upon the concrete by its long exposure to heat, practically that of the melting point of brass, together with the sudden cooling by a forceful stream of water, prove conclusively the intrinsic value of "DRAGON" Portland Cement as a fire resisting material when properly combined with good concrete aggregates.

EXTRACT FROM REPORT OF A FIRE, LOAD AND WATER TEST MADE UPON REINFORCED CONCRETE FLOORS, BEAMS, GIRDERS AND COLUMNS.

Test conducted on Westchester Avenue, between Brooke and St. Annes Avenues, Borough of Bronx, New York City, Sept. 20th, 1906.

WEATHER OBSERVATIONS.

Day cloudy, with light rain—Practically no wind.
Temperature—75-80° F.
Age of floor when tested—30 days.
Test started—East Building, 11:00 a. m.
West Building, 11:20 a. m.
Water applied—East Building, 3:06 p. m.
West Building, 3:24 p. m.

METHOD OF CONSTRUCTION.

The test house was double, having two chambers, one 14'x13' on the inside, and the other 14'x11' 4", with a 12" concrete partition between them. The walls were 8" thick and constructed of reinforced concrete throughout. The building had eight chimneys and suitable draft openings for each chamber at the

FIGURE 12.
RESULT OF A HEAT TEST OF DRAGON CEMENT CONCRETE AT 1700° F. FOR FIVE HOURS. (*See Report.*)

bottom. The grate was 2′ 6″ above the ground level. The ceiling was 9′ 6″ above the grate.

The floor systems tested constituted the roof of the building.

FLOOR OF EAST CHAMBER.

The floor of the larger (East) chamber consisted of a 4″ reinforced stone concrete floor slab carried upon two 14′ reinforced concrete girders. These girders were 17½″ deep, including the floor slab of which they formed a part, and 10″ in width. They were spaced 6′ 8″ on centers, giving an actual clear span of the floor slab between girders of 5′ 10″. The reinforcing metal of the floors, beams and girders was of the form of . . . . . . (a unit frame), and consisted of round rods. At the wall, these rods were threaded and had washers screwed on them. The ends of all slab reinforcement, together with beams and girders that were continuous and did not enter the outside walls, were hooked, that is, the rods were turned at a right angle 3″ from the end. These reinforcing rods, arranged as shown in attached detail drawing were 1¼″ in diameter and spaced on 2½″ centers in the beams; and ½″ in diameter, spaced 4⅞″ on centers in the floor slabs. The single column tested was placed under the west girder in this chamber, 3′ 8″ from the north wall.

The column reinforcement consisted of four ⅝″ vertical rods which were held together by ¼″ square iron ties spaced 10″ apart.

FLOOR IN WEST CHAMBER.

The floor system in the smaller (West) chamber was similar to the larger with respect to the method of construction, but the floor was made 3½″ thick and carried on girders 5′ on centers giving a clear floor span of 4′ 2″. The reinforcing rods were spaced 2½″ on centers in the girders, and 5¾″ on centers in the floor slab.

The concrete for the entire construction was a 1-2-4 mixture of (DRAGON) Portland cement, clean sand and ¾″ broken trap rock.

The ceilings were not plastered.

PURPOSE OF THE TEST.

The purpose of the test was to determine the effect of a continuous fire below the floor for four hours at an average temperature of 1700° F., the floor carrying at the same time a distributed load of 150 lbs. per sq. ft.; at the end of the four hours the

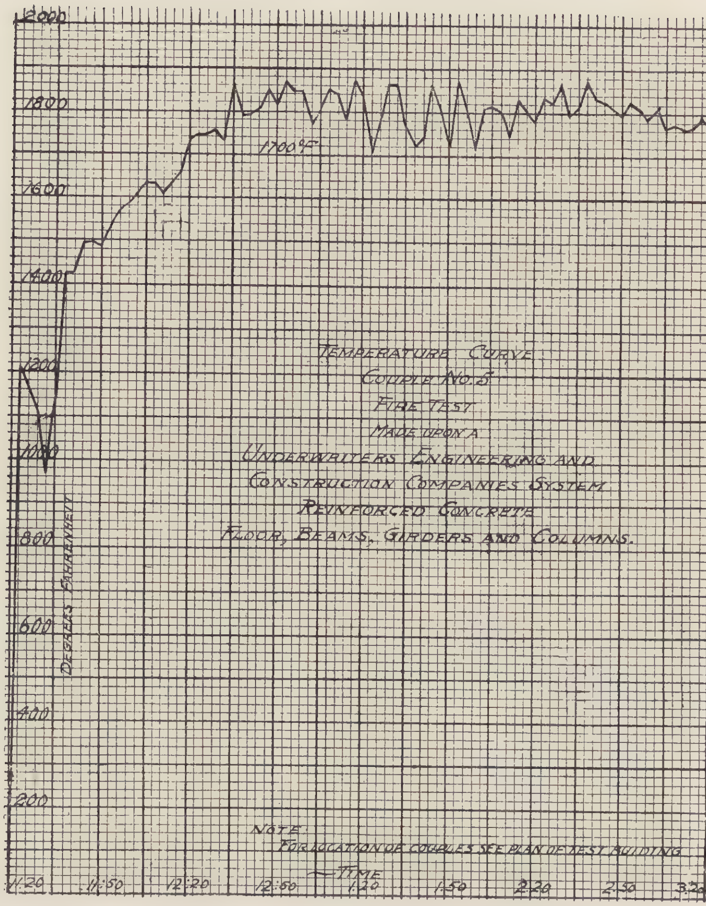

2000
1800
1700°F
1600
1400
1200
1000
800
600
400
200
DEGREES FAHRENHEIT
TEMPERATURE CURVE
COUPLE NO. 5
FIRE TEST
MADE UPON A
UNDERWRITERS ENGINEERING AND
CONSTRUCTION COMPANIES SYSTEM
REINFORCED CONCRETE
FLOOR, BEAMS, GIRDERS AND COLUMNS.
NOTE:
FOR LOCATION OF COUPLES SEE PLAN OF TEST BUILDING
—TIME
11:20
11:50
12:20
12:50
1:20
1:50
2:20
2:50
3:20

FIGURE 13.

under side of the floor (or ceiling) while still red hot to be subjected to a $1\frac{1}{8}''$ stream of cold water at short range, through 100′ of hose under 60 ℔s. pressure at the nozzle for five minutes, then the upper side of the floor (which forms the roof of the test building) to be flooded at low pressure; afterwards the stream to be again applied at full pressure on the underside for five minutes longer.

Deflection of beams and floor to be measured continuously during the test. The load then to be removed and when cold reloaded to 600 ℔s. per sq. ft. and deflection noted.

TEMPERATURES.

The temperatures of the fire were obtained by electric pyrometer couples suspended through the floors from above and hanging about 6″ below the ceiling.

Readings were made upon each couple every three minutes. The fuel used was dry cord wood, the frequency of firing being determined by the temperature of the test chambers. The .. ..plotted curve for one couple in each test chamber is herewith attached.

DEFLECTIONS.

The deflections which occurred during the test were measured by a Y level reading upon rods located upon the ends and middle of each girder, also upon the middle of the floor slab.......... "Deflection Diagram" shows the relative position of the three members graphically at different times.

WATER.

The water was applied by firemen with an engine from the Bronx Fire Department. The pressure gauge was carefully watched and full 60 ℔s. maintained.

In applying the water the stream was thrown back and forth over the whole ceiling as much as possible and not allowed to strike continuously on one spot. In the east chamber the water was applied continuously for ten minutes at full pressure. In the west chamber full pressure was maintained for five minutes, then dropped to 30 ℔s. and applied to the roof for 2 minutes, then applied to the ceiling again at full pressure for five minutes longer.

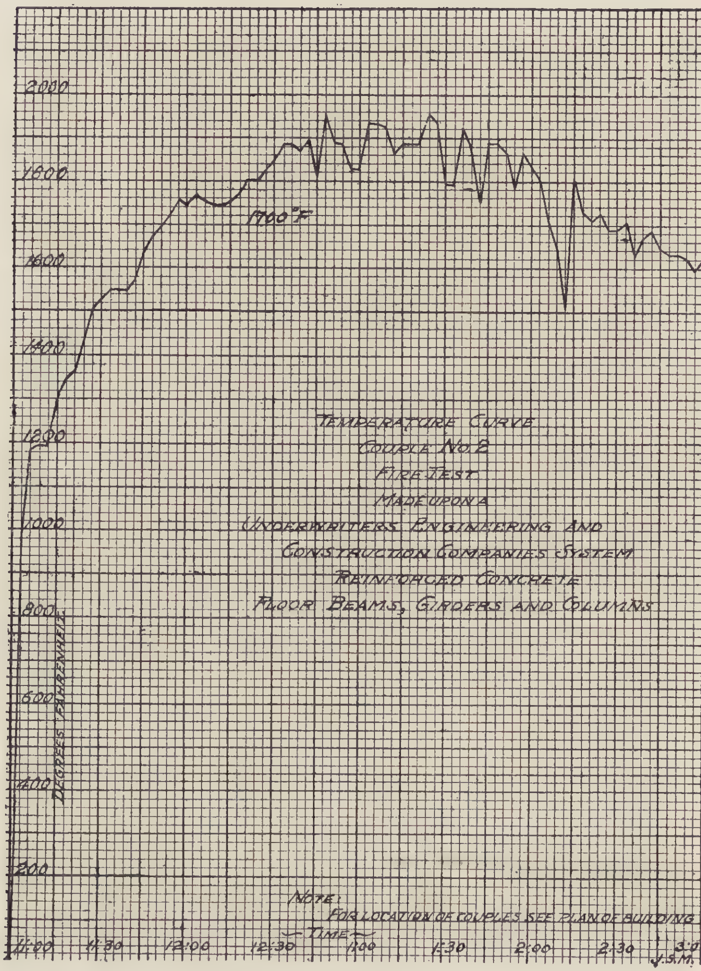

2000
1800
1600
1400
1200
1000
800
600
400
200
1700°F
DEGREES FAHRENHEIT
TEMPERATURE CURVE
COUPLE NO. 2
FIRE TEST
MADE UPON A
UNDERWRITERS ENGINEERING AND
CONSTRUCTION COMPANIES SYSTEM
REINFORCED CONCRETE
FLOOR BEAMS, GIRDERS AND COLUMNS
NOTE:
FOR LOCATION OF COUPLES SEE PLAN OF BUILDING
11:00
11:30
12:00
12:30
— TIME —
1:00
1:30
2:00
2:30
3:0
J.S.M.

FIGURE 14.

EFFECTS OF THE TEST.

EAST CHAMBER—4 INCH FLOOR.

Twenty minutes after starting the fire several explosions were heard and it was noted that a patch of concrete about 12"x18" had fallen from the middle of the floor span and exposed two of the reinforcing rods for about 9 inches of their length....... The girders and column were apparently intact up to the time of application of water.

The effect of the water was to knock off the concrete from the bottom of the girders and from the exposed side of the column.

....

The floor slab was pitted to a depth of ¼ to ¾ of an inch where subjected to the direct action of the stream of water but very little metal was exposed.............

The final load of 600 lbs. per sq. ft. produced a deflection in the slab of only 29-32 of an inch.

WEST CHAMBER—3½ INCH FLOOR.

..............A crack appeared in the floor slab on the roof 1½ hours after starting the test. It ran through the middle of the slab and opened about 1-16 of an inch. Half an hour later a piece of concrete about two feet square and varying in thickness from a thin edge to two inches, was lifted from the top surface of the floor slab on the north end and about a foot from the east girder. This was a very unusual occurrence, and whether it was due to an explosion of steam in the concrete or to some other cause was not apparent. It was probably due to superheated steam held in by the blanket of sand bags which were used for loading.......................

The floor slab was slightly pitted but otherwise in excellent condition. (See photo for details of condition of floor after test.)

By way of experiment a small hole was made in the concrete on the roof running down to the top of the metal rods in the east girder about a foot from the north pilaster column. In this hole a mercury thermometer was placed. During the first half of the test the hole was filled with boiling water but later dried out and the temperature began to rise until at the end of the test it had reached 520° F. This temperature was not as high as was expected. ...... It indicates that the concrete retards the transfer of heat even in the steel rods imbedded in it.

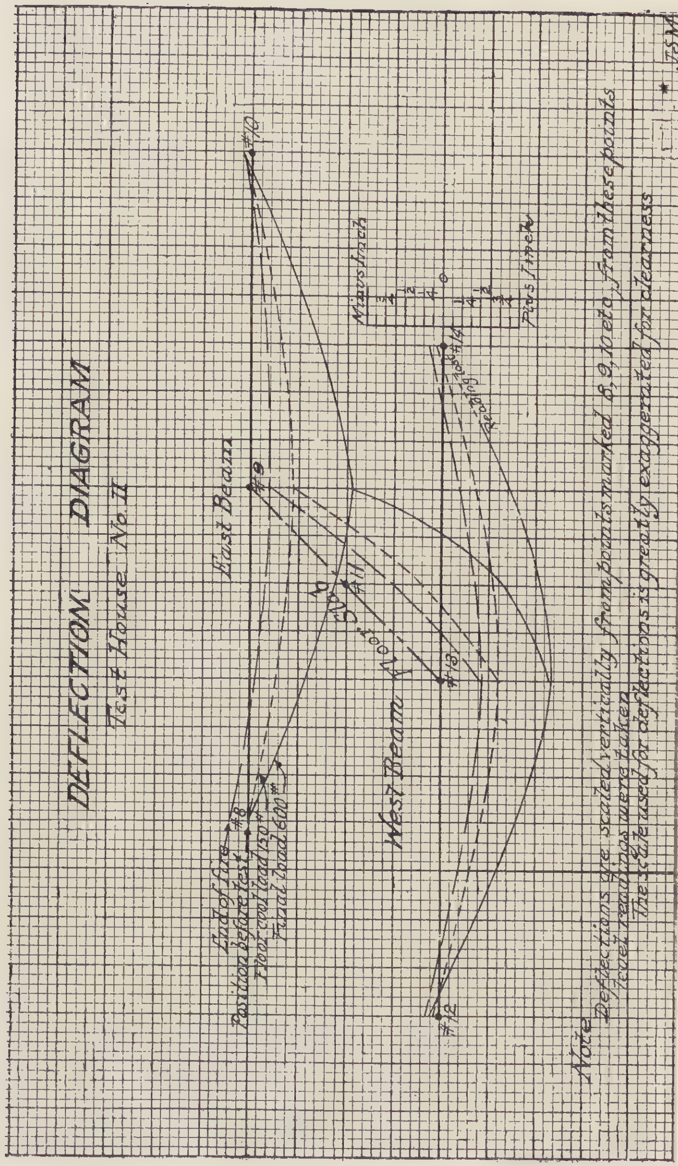

DEFLECTION DIAGRAM
Test House No. II
East Beam
West Beam
End of fire
Position before test
Floor cool load 150#
Final load 600#
Minus 1 inch
Plus 1 inch
Note
Deflections are scaled vertically from points marked 8, 9, 10 etc, from these points
level readings were taken
The scale used for deflections is greatly exaggerated for clearness
JSM

FIGURE 15.

The final load of 600 lbs. per sq. ft. was carried with a center deflection of the floor span of 11-16 of an inch.

The tests were conducted in co-operation with the Bureau of Buildings of the city....................

Respectfully submitted,

(Signed) Ira H. Woolson.

TABLE OF CORRECTED TOTAL DEFLECTIONS.

Test House No. 1.

(East Chamber, 4″ Floor.)

For middle of beams, taking into account the rise of ends of beams.

Sept. 20, 3:00 P. M.—	East Beam	Middle Floor Slab	West Beam
150 lbs. per sq. ft....	1 6-16″	1″	4-16″
Sept. 21, 9:00 A. M.—			
150 lbs. per sq. ft....	29-32″	7-32″	11-32″
1:20 P. M.—			
600 lbs. per sq. ft....	1 11-32″ *	22-32″	23-32″ *

* Estimated.

Note—The results above are obtained as follows: For all beam deflections when the ends rise and the middle falls, add the middle deflections to the mean of the two end rises. When the ends and middle fall, subtract. (Table of observed elevations not given.)

CORRECTED TOTAL DEFLECTIONS.

Test House No. 2.

(3½″ Floor.)

For middle of beam, taking into account the rise of ends of beams.

Sept. 20, 3:20 P. M.—	East Beam	Middle Floor Slab	West Beam
150 lbs. per sq. ft....	7-16″	7-32″	12-16″
Sept. 21, 9:00 A. M.—			
150 lbs. per sq. ft....	10-16″	6-16″	12-16″
4:25 P. M.—			
600 lbs. per sq. ft....	1 6-16″	11-16″	1 13-32″ *

* Estimated.

See Note on previous table.

O W ROBERTSON, Milwaukee
President
A. T HOWE, Chicago
Vice President

R C BROWN Oshkosh
Secretary
CHAS WEILER Milwaukee
Treasurer

PORTLAND CEMENTS

WESTERN LIME & CEMENT CO.

WISCONSIN WHITE LIME

DAILY CAPACITY 10,000 BARRELS.

PLASTER, PLASTERING HAIR,
FIRE BRICK & FIRE CLAY.

ROOMS-509-510-511-512
PABST BUILDING

MILWAUKEE, Apr. 3, 1907

Lawrence Cement Co.,
Philadelphia.

Gentlemen:-

The writer has just made a careful inspection of the concrete building in which an explosion of acetylene gas yesterday killed or injured everyone in it. This was a concrete structure erected entirely of Dragon Cement, and had numerous large windows and door ways. The concrete frame work on this building is absolutely intact, as there is not a single crack or blemish on the entire concrete work on the structure, while the windows and doors and woodwork have been blown to atoms. The owner of the building is fortunate in losing nothing but the wood and glass work on the building. Had it been of brick, stone or frame, it would have been an entire ruin. As it is, there is nothing to replace excepting glass and wood and the entire concrete structure is as sound today as when it was first uncovered.

Yours truly,

WESTERN LIME & CEMENT CO.

Similar practical tests were experienced in the Baltimore fire, as observed by Professor Charles L. Norton, and reported by him to the Insurance Engineering Experiment Station of Boston. Professor Norton writes as follows:

" In the International Trust Company Building a small paper room, having a (reinforced concrete) floor and ceiling, was so intensely heated that at the end of three days the lumps of cast-iron which had earlier been a copying press and an embossing stamp were still red hot and yet neither floor nor ceiling showed signs of distress. This is the more remarkable in that the walls of the adjoining building fell through the skylights upon this floor."

Professor Norton says further:

" Where concrete floor arches and concrete-steel construction received the full force of the fire it appears to have stood well, distinctly better than the terra cotta.

" The general condition of the fire-proof building is such as to indicate to my mind the unfitness of terra cotta for beam and post covering and floor constructions as were used when compared with concrete or brick-work."

Professor Norton explains the heat resisting property of concrete as follows:

" Little difference in the action of the fire on stone concrete and cinder concrete could be noted, and as I have earlier pointed out, the burning of the bits of coal in poor cinder concrete is often balanced by the splitting of the stones in the stone concrete. I have never been able to see that in the long run either stood fire better or worse than the other. However, owing to its density, the stone concrete takes longer to heat through. When brick or terra cotta are heated no chemical action occurs, but when concrete is carried up to about 1000 degrees Fahrenheit its surface becomes decomposed, dehydration occurs, and water is driven off. This process takes a relatively great amount of heat. It would take about as much heat to drive the water out of this outer quarter-inch of the concrete partition as it would to raise that quarter-inch to 1000 degrees Fahrenheit. Now a second action begins. After dehydration the concrete is much improved as a non-conductor, and yet, through this layer of non-conducting material must pass all the heat to dehydrate and raise the temperature of the layers below, a process which cannot proceed with great speed."

Time and again concrete buildings have shown their superiority over those erected of brick with ordinary floor construction

THE
HAMILTON-PARKER
FUEL & SUPPLY CO.
MANUFACTURERS OF
TRADE MARK
MASTIC
WOOD FIBER
PLASTER
COLUMBUS, OHIO.

ALL QUOTATIONS FOR IMMEDIATE ACCEPTANCE, UNLESS OTHERWISE STATED

The Hamilton-Parker Fuel & Supply Co.

DEALERS AND SHIPPERS

HOCKING, WEST VIRGINIA, BLOSSBURG COAL AND COKE
ALL KINDS OF BUILDERS' MATERIAL

Office, Mill and Warehouse: 491-501 Kilbourne Street

CITIZEN PHONE 2977
BELL PHONE - 2811

Columbus, Ohio, November 11th, 1908.

Colonnial Coal & Supply Co.,
Columbus, Ohio.

Gentlemen:-

We wish to advise you that the Dragon Portland Cement, for which you are the County agents, is giving us entire satisfaction. Our Contractors using this cement, are surprised at its color, strength, and working qualities. For sidewalk work it finishes in an extremely light color, something different from other cements, and we are advised by the cement block manufacturers that they can make one more block out of Dragon Portland Cement than they can out of the same quantity of other Portlands.

We believe our sales for the next season will increase as the cement has not been used very much in this market before this year. We are perfectly satisfied with the results obtained from this cement, and expect to increase our sales considerably next year, the cement having been introduced thoroughly in the past season.

Yours truly,
The Hamilton Parker Fuel & Supply Co.,
Per. D. Shertzer Mgr

by the confining of the fire in the concrete building to a single floor, while a brick building adjoining was practically wrecked by the conflagration. Such a case occurred in Dayton, Ohio, and the technical magazines described the conditions in detail.

This fire was also made the subject of a special examination by the chairman of the committee on concrete and reinforced concrete of the National Fire Protection Association, who writes as follows:

"It must be conceded that the concrete itself stood the test very well indeed, especially in view of the fact that the ordinarily constructed building adjoining was much more seriously damaged by the same fire and under the same fire department protection."

The same report also describes another fire as follows:

"On May 27th, 1907, a fire occurred in Merritt Brothers' Factory at Camden, N. J., which in a building of ordinary construction would doubtless have resulted disastrously, proved, under the circumstances, to be chiefly a demonstration of the fire resistive quality of the building.

"The building in which this fire occurred is a five-story structure, occupied for the manufacture of metal clothes closets for factories. The columns, beams, floors and roof are of heavy type reinforced concrete, the mixture being 1:2½:5 small size, crushed trap rock. The walls, brick carried on a concrete frame. The fifth story was occupied for painting and drying. In the corner of the room were two wooden, gas heated drying ovens, approximately 7x10x8 ft., and along the side of the room next to this were a number of smaller ovens, all of metal construction.

"The fire lasted from ½ to ¾ of an hour, practically burned up the wooden ovens and some other light inflammable materials close by. The flames did not extend very far into the room, however, though there was enough heat to melt out the soldered metal frames of the wire glass monitors on the roof a little to one side of the ovens, to melt the links on two fire doors 40 to 50 feet away. The concrete columns and ceiling in the immediate vicinity of the fire showed some cracks, but no material injury, and absolutely no repairs of any sort were made to the concrete after the fire, the only repairs being those made to the above-mentioned wire glass window frames."

In the Chelsea fire, few examples of concrete construction were tested, but the Chelsea Armory happened to have been built with concrete foundations and with concrete sills and lin-

tels. In general, the concrete work stood the heat well, although a few of the sills which appeared to have been mixed of mortar with too small a proportion of water, showed cracks. On the principal doorway to the armory, the ornamental surface of the concrete was somewhat chipped but the interior was sound, while the adjacent brick wall was badly chipped on the face, although the wall was built of hard burned, cherry brick.

Such examples might be cited indefinitely, but invariably the same comment is made by disinterested investigators, that properly made concrete is the most effective fire resisting material known to mankind. Consequently, " DRAGON " Portland Cement, when properly mixed with good sand and stone, can be depended upon to save insurance, reduce liability of loss, and prevent the disastrous conflagrations which annually sweep through our great cities.

Concrete Blocks.

Hollow concrete building blocks, *properly made and used,* form an ideal material for the exterior walls of buildings, replacing that part which if built of wood rapidly deteriorates from exposure to the weather. Buildings constructed of blocks are as reasonable in first cost as if built of frame, and are much less expensive for maintenance. They have all the advantages of brick and stone in point of comfort, namely, coolness in summer and warmth in winter.

In selecting materials for concrete blocks, those should be chosen which will produce a mixture of the greatest possible density. This fact should be determined by experiment, by mixing available samples of sand and gravel, and the results thus obtained should be carefully followed in proportioning mixtures for all work. A considerable proportion of coarse material is just as necessary as in other kinds of concrete work, and gravel or stone screenings should be employed with this point in view.

There are four important points which must be kept in view in adjusting the proportions of materials for block concrete,—endurance, strength, permeability and cost. The endurance depends primarily upon the cement employed, although certain qualities of sand and certain deleterious materials in the water employed sometimes cause trouble. As to strength, it is doubtful whether blocks of satisfactory quality can be made under ordinary factory conditions, wherein mixing and tamping are done by hand, from a poorer mixture than 1 to 5.

The proportion of water to be used is a matter of the utmost consequence, and has more effect on the quality and strength of the work than is generally supposed. Blocks made from too dry concrete will always remain soft and weak, no matter how thoroughly sprinkled afterward. Careful steam curing is the only remedy and the effect of this treatment is not approved without qualification by many block makers. On the other hand, if blocks are to be removed from the machines as soon as made, too much water will cause them to stick to the plates and sag out of shape. It is practically possible, however, to so proportion the

Cement Block Residence.
Blocks Made of and Laid With "Dragon" Portland Cement.

water as to secure density and good hardening properties and still be able to remove the blocks at once from the molds. A high proportion of coarse material allows the mixture to be made proportionately wetter without sticking or sagging. The general rule to be followed is:

"Use as much water as possible without causing the blocks to stick to the plates or change shape on being removed from the machine."

This amount of water varies with the materials but is generally slightly less than 10% of the weight of the dry material, and an experienced manufacturer can judge accurately when the right amount of water has been employed by squeezing some of the mixture in his hand.

Slight variations in the proportion of water make a marked difference in the quality and color of the blocks, so that when the proper quantity has been determined for any set of materials that quantity should always be accurately measured out for each batch. Materials should be mixed in the dry state until the combination is uniform in color and the parts are perfectly combined. Then the water is to be added and the mixing continued until all parts are of equal humidity and every particle coated with cement paste.

Hand mixing is always imperfect and slow. A machine seldom gets tired and the output is usually limited only by the facility with which material can be taken away. In the manufacture of concrete blocks, batch mixers are far superior to continuous ones, because it is absolutely essential that only measured quantities of each kind of material are found in combination at every stage, else variations in color and quality will be inevitable. Hand tamping must be conscientious and thorough. It is best that the mold be filled layer by layer, carefully tamping each addition but not so as to produce lines of stratification. At least four such fillings and tampings should be given each block.

Blocks should not be used in buildings before at least four weeks from the day on which they were made. During this period of seasoning, blocks will be found to shrink about 1-16" in length. This shrinkage would cause cracks in any finished structure erected with green blocks. Seasoning of blocks should be done under cover where they are not subject to draughts or other effects of direct sun or wind. Watering should be done regularly and in proper amount. Efflorescence or the appearance of a white coating on a block sometimes takes place when it is periodically saturated and then dried out. Blocks placed di-

J. B. ARBOUR, GEN'L MGR. A. H. STARR, SEC'Y AND TREAS

NATIONAL BUILDERS SUPPLY COMPANY

DEALERS AND MANUFACTURERS

WHOLESALE BUILDERS SUPPLIES AND CONCRETE BLOCKS

OFFICE AND FACTORY, 410 GEORGE STREET

W. VA. PHONE 1408 BELL PHONE 630

PARKERSBURG, W. VA.

Nov 12th, 1908

Cumberland Hyd Cement & Mfg Co.,
Cumberland, Md.

Gentlemen:-

In our five years experience with Dragon we have yet to see it fail to meet any demand put upon it by Engineer or Mechanic. In our Concrete Block work we consider it the peer of any Portland Cement manufactured.

Very truly yours,

NATIONAL BUILDERS SUPPLY CO.

PER J B Arbour MGR.

rectly on the ground are most liable to show this defect. This efflorescence is due to the diffusion of soluble sulphate and alkali to the surface and will always disappear in time.

The chief fault of ordinary concrete building blocks is their tendency to absorb water. They are, however, generally no worse than common brick and some kinds of stone. Brick and stone walls (unless specially treated) are too permeable to allow of plastering directly on the interior surface, thus making furring and lathing necessary. The same practice should generally be followed with concrete block buildings. The popularity and usefulness of this class of construction would be greatly increased if blocks could be made sufficiently water-proof to allow plastering directly on the interior surface. An absolutely water-proof block, however, is not wise because it has a tendency to sweat from condensation of moisture from the air. Walls should be slightly porous so that any moisture formed on them may be gradually absorbed, and later evaporated. With this point in view blocks should be so made that their absorption of water will be slow. For this purpose, a good mixture of sand and gravel, which would contain about 25% voids, will give a fairly impermeable concrete in mixtures up to 1 to 4; but when larger proportions are used the blocks will be found quite absorbent. In order to make a block as impermeable as possible the voids must be filled with some material. This work is sometimes done with cement, which, however, is an expensive method and gives stronger concretes than are needed. The same result can be somewhat more cheaply accomplished by substituting a small percentage of slaked lime for a part of the cement. Hydrate of lime is the most convenient material, but its cost is practically as high as that of cement and carefully slaked lumped lime is more often employed. Sometimes, an impervious layer is placed near the face or through the center of a block, and with so-called "two-piece" systems the penetration of moisture through a wall is prevented by leaving an air space between the two faces of the block. Special water-proofing compounds are also employed and occasionally surface coatings have been employed with more or less success. Such coatings, however, should be composed of materials which are not affected by the free alkali in the cement which will saponify most oils. The primary condition for securing high impermeability is the use of a sufficiently wet concrete.

The selection of a proper cement for use in concrete block manufacture is of the utmost importance. Only a so-called

" sound " cement can be used in the manufacture of concrete blocks which are made to resist the action of time, water and atmospheric gases. An excess of " freelime " will in time become hydrated, and swell, exerting such great force as to disintegrate what may have been blocks which have proved hard for a long period. Certain brands of cement are much more liable to this tendency than others. Some mills are provided with insufficient grinding machinery and the resulting poor grinding is apt to make a cement which is unsound while it is still fresh. Such producers rely upon seasoning during transit, etc., to make their product sound, and when pushed for their product sometimes ship freshly made cement which consequently is unsound. It usually costs less to make an unsound cement than a sound one because less care is needed in proportioning the raw materials. Less grinding of the raw mix is necessary and less coal may be employed in burning it. Portland cement which has stood a tensile strain of 350 pounds to the square inch at the end of thirty days when mixed with three parts of sand has been known to entirely disintegrate by the end of a year. Sometimes unsoundness is produced by the addition of an extra amount of gypsum. This can only be detected either by long time tests or a chemical analysis. Occasionally, chemicals which may be added to the cement in an endeavor to secure a particular color will affect its soundness deleteriously. Those chemicals which produce a quick setting cement are causes of unsoundness to a marked degree and should never be used except on the advice of an experienced chemist. They also cause efflorescence on the block.

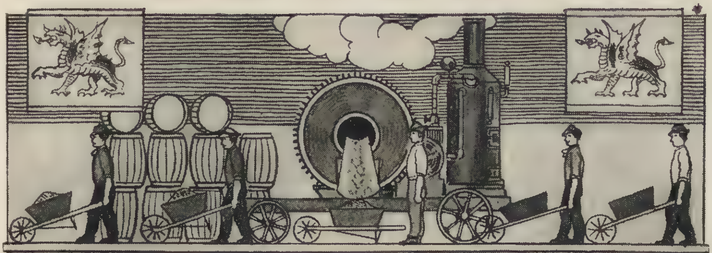
The strength of cement is not to be gauged by the results of neat tests but should invariably be made to depend upon long time experiments on sand mixtures. The finer the cement the stronger the resulting product. By a fine cement is not necessarily meant a cement so ground as to show a good sieve test, but rather a cement that contains a large percentage of flour. The same cement may also happen to contain a large percentage of coarse materials. The setting time of a cement has also been found to bear an important relation to its strength. Slow setting cements are apt to be stronger than those which set more quickly. Quick setting cements, that is those that set inside of four hours, are apt to be over clayed and are apt to contain less of the active materials to which cement owes its strength. Occasionally a cement is encountered with a " flash " set, that is, one which will set up under the trowel. The quick set of such

cements is broken by working, and consequently blocks made with it are apt to be very weak. In distinction from a "slow setting cement," one of the greatest requisites for block manufacture is, the cement shall be a "quick hardener," that is, it must not secure its permanent set inside of six hours but at the end of seven days should be practically as hard as at the end of six months. Quick setting cements are not necessarily prompt hardeners; they are usually the reverse. A high seven day sand test is an indication of prompt hardening.

A concrete block manufacturer will probably be more interested in the color of his blocks and their uniformity in this respect than in any other one of their properties. Uniformity can only be secured by the use of a cement of uniform color mixed with sand which also is uniform in color, quantity and quality, and combined with a uniform amount of pure water. A cement which was absolutely free from iron and manganese would be white in color, and cement becomes darker as the percentage of these ingredients increases. Most cements are practically free from manganese. Sulphate of iron is sometimes encountered in certain cements; this causes dirty brown spots to appear in the work from the oxidation of the iron. Under-burned cements also often show the same dirty brown color throughout the whole mass.

For these reasons cement block manufacturers *should purchase only "DRAGON" Portland Cement* which has been proved by long time tests as particularly uniform with regard to its soundness, fineness, setting time, hardening quality, tensile strength and color. (See pages 106 and 114.)

Northampton County Jail, Easton, Pa.
Blocks Made of and Laid With "Dragon" Portland Cement.



Standard Specifications—

FOR CEMENT HOLLOW BUILDING BLOCKS.

As adopted January, 1908, by National Association of Cement Users, Philadelphia, Pa.

Regulations Governing Use and Manufacture.

Hollow cement blocks made in accordance with the following specifications, and meeting the requirements thereof, may be used in building construction, subject to the usual form of approval, required of other materials of construction, by the bureau of building inspection.

The cement used in making blocks shall be Portland cement, capable of passing the requirements as set forth in the "Standard Specifications for Cement," of the American Society for Testing Materials, and adopted by this Association (Specification No. 1) January, 1906.

The sand used shall be suitable siliceous material, passing the one-fourth inch mesh sieve, clean, gritty and free from impurities.

The stone aggregate shall be clean broken stone, free from dust, or clean screened gravel passing the three-quarter (¾) inch, and refused by the one-quarter (¼) inch mesh sieve.

The barrel of Portland cement shall weigh 380 pounds net, either in barrels or sub-divisions thereof, made up of cloth or paper bags, and a cubic foot of cement shall be called not to exceed 100 pounds or the equivalent of 3.8 cubic feet per barrel. Cement shall be gauged or measured either in the original package as received from the manufacturer, or may be weighed and so proportioned; but under no circumstances shall it be measured loose in bulk.

For exposed exterior or bearing walls.

THIS PICTURE SHOWS VIEW OF TINKER CONCRETE & NATIONAL VAULT CO.'S STORAGE YARD, SHOWING CONCRETE VAULTS MANUFACTURED BY THEM, ALSO CONCRETE BLOCKS MANUFACTURED FROM "DRAGON" PORTLAND CEMENT.

(*a*) Hollow cement blocks, machine made, using semi-wet concrete or mortar, shall contain one (1) part cement, not to exceed three (3) parts sand, and not to exceed four (4) parts stone of the character and size before stipulated. When the stone shall be omitted the proportions of sand shall not be increased, unless it can be demonstrated that the percentage of voids and tests of absorption and strength allow in each case of greater proportions with equally good results.

(*b*) When said blocks are made of slush concrete, in individual molds and allowed to harden undisturbed in same before removal, the proportions may be one (1) part cement to not exceed three (3) parts sand and five (5) parts stone, but in this case also, if the stone be omitted the proportion of sand shall not be increased.

Thorough and vigorous mixing is of the utmost importance.

(*a*) Hand mixing. The cement and sand in correct proportions shall first be perfectly mixed dry, the water shall then be added carefully and slowly in proper proportions and thoroughly worked into and throughout the resultant mortar; the moistened gravel or broken stone shall then be added, either by spreading the same uniformly over the mortar, or spreading the mortar uniformly over the stones, and then the whole mass shall be vigorously mixed together until the coarse aggregate is thoroughly incorporated with and distributed throughout the mortar.

(*b*) Machine mixing. Preference shall be given to machine mixers of suitable design and adapted to the particular work required of them; the sand and cement, or sand and cement and moistened stone shall, however, be first thoroughly mixed before the addition of water, and then continued until the water is uniformly distributed or incorporated with the mortar or concrete; *provided,* however, that when making slush or wet concrete (such as will quake or flow) this procedure may be varied with the consent of the bureau of building inspection, architect or engineer in charge.

Due care shall be used to secure density and uniformity in the blocks by tamping or other suitable means of compression. Tamped blocks shall not be finished by simply striking off with a straight edge, but, after striking off, the top surface shall be trowelled or otherwise finished to secure density and a sharp and true arris.

Every precaution shall be taken to prevent the drying out of the blocks during their initial set and first hardening. A sufficiency of water shall first be used in the mixing to perfect the

WORKS—EAST FIFTH ST. OFFICE—108 MARKET ST
BELL PHONE 244

MODERN CONCRETE BLOCK RESIDENCE

Warren Concrete Stone Co.
(Limited)

MANUFACTURERS OF

HOLLOW CONCRETE BUILDING BLOCKS
CONCRETE CAPS, SILLS, COPING,
WATERTABLE, CURBING, ETC.

AGENTS DRAGON PORTLAND CEMENT
ESTIMATES CHEERFULLY FURNISHED

WARREN, PA.,

December 4, 1908.

The Cumberland Hyd. Cement & Mfg Co.,
Cumberland, Md.

Dear Sirs:-

In all the work in which we have used your "Dragon" Portland cement in this vicinity we have yet to find one instance where it has not stood every test we have given it perfectly and we cannot recommend it too highly.

We especially prize "Dragon" on account of the lightness in color of the finished concrete product, in our manufacture of building blocks uniformity of color and maximum strength count for much and the results obtained from the use of your cement are highly satisfactory to us.

We are pleased to be numbered among your customers.

Yours very truly,

Warren Concrete Stone Co., Ltd.,

Per H. H. McHenry

crystallization of the cement, and, after molding, the blocks shall be carefully protected from wind-currents, sunlight, dry heat or freezing for at least five (5) days, during which time additional moisture shall be supplied by approved methods, and occasionally thereafter until ready for use.

Hollow cement blocks in which the ratio of cement to sand be one-third (1/3) (one part cement to three parts sand) shall not be used in the construction of any building until they have attained the age of not less than three (3) weeks.

Hollow cement blocks in which the ratio of cement to sand is one-half (1/2) (one part cement to two parts sand) may be used in construction at the age of two (2) weeks, with the special consent of the bureau of building inspection and the architect or engineer in charge.

Special blocks of rich composition, required for closures, may be used at the age of seven (7) days with the special consent of the same authorities.

The time herein named is conditional, however, upon maintaining proper conditions of exposure during the curing period.

All cement blocks shall be marked, for purposes of identification, showing name of manufacturer or brand, date (day, month and year) made, and composition or proportions used, as, for example, 1-3-5, meaning one cement, three sand and five stone.

The thickness of bearing walls for any building where hollow cement blocks are used may be ten (10) per cent. less than is required by law for brick walls. For curtain walls or partition walls, the requirements shall be the same as in the use of hollow tile, terra cotta or plaster blocks.

Hollow cement blocks shall not be permitted in the construction of party walls, except when filled solid.

Where the face only is of hollow cement block, and the backing is of brick, the facing of hollow block must be strongly bonded to the brick, either with headers projecting four (4) inches into the brick work, every fourth course being a header course, or with approved ties, no brick backing to be less than eight (8) inches. Where the walls are made entirely of concrete blocks, but where said blocks have not the same width as the wall, every fifth course shall extend through the wall, forming a secure bond, when not otherwise sufficiently bonded. All walls, where blocks are used, shall be laid up with Portland cement mortar.

Wherever girders or joists rest upon walls so that there is a concentrated load on the block of over two (2) tons, the blocks

Residence of William Buckholtz, La Vale, Cumberland, Md.
B[illegible] Made and Laid With "Dragon" Portland Cement.

supporting the girder or joists must be made solid for at least eight (8) inches from the inside face. Where such concentrated load shall exceed five (5) tons, the blocks for at least three courses below, and for a distance extending at least eighteen (18) inches each side of said girder, shall be made solid for at least eight (8) inches from the inside face. Wherever walls are decreased in thickness, the top course of the thicker wall shall afford a full solid bearing for the webs or walls of the course of blocks above.

No wall, nor any part thereof, composed of hollow cement blocks, shall be loaded to an excess of eight (8) tons per superficial foot of the area of such blocks, including the weight of the wall, and no blocks shall be used in bearing walls that have an average crushing at less than 1,000 pounds per square inch of area at the age of twenty-eight (28) days; no deduction to be made in figuring the area for the hollow spaces.

Concrete sills and lintels shall be reinforced by iron or steel rods in a manner satisfactory to the bureau of building inspection and the architect or engineer in charge, and any lintels spanning over 4 feet 6 inches shall rest on block solid for at least 8 inches from the face next the opening and for at least three courses below the bottom of the lintel.

The hollow space in building blocks used in bearing walls shall not exceed the percentage given in the following table for different height walls, and in no case shall the walls or webs of the block be less in thickness than one-fourth their height. The figures given in the table represent the percentage of such hollow space for different height walls:

Stories	1st	2d	3d	4th	5th	6th
1 and 2	33	33				
3 and 4	25	33	33	33		
5 and 6	20	25	25	33	33	33

Before any such material be used in buildings, an application for its use and for a test of the same must be filed with the bureau of building inspection. In the absence of such a bureau, the application shall be filed with the chief of any department having such matters in charge. A description of the material and a brief outline of its manufacture and proportions used must be embodied in the application. The name of the firm or corporation, and the responsible officers thereof, shall also be given, and changes in same thereafter promptly reported.

No hollow cement blocks shall be used in the construction of

any building unless the maker of said blocks has submitted his product to the full tests required herein, and placed on file with the bureau of building inspection, or other duly authorized official, a certificate, from a reliable testing laboratory, showing that representative samples have been tested and successfully passed all the requirements hereof, and giving in detail the results of the tests made.

No cement blocks shall be used in the construction of any building until they have been inspected and approved, or, if required, until representative samples be tested and found satisfactory. The results of all tests made, whether satisfactory or not, shall be placed on file in the bureau of building inspection. These records shall be open to inspection upon application, but need not necessarily be published.

The manufacturer and user of such hollow cement blocks, or either of them, shall, at any and all times, have made such tests of the cements used in making such blocks, or such further tests of the completed blocks, or of each of these, at their own expense and under the supervision of the bureau of building inspection, as the chief of said bureau shall require.

In case the result of tests made under this condition should show that the standard of these regulations is not maintained, the certificate of approval issued to the manufacturer of said blocks will at once be suspended or revoked.

Following the application called for in clause No. 18 and upon the satisfactory conclusion of the tests called for, a certificate of approval shall be issued to the maker of the blocks by the bureau of building inspection. This certificate of approval will not remain in force for more than four months, unless there be filed with the bureau of building inspection, at least once every four months following, a certificate from some reliable physical testing laboratory showing that the average of at least three (3) specimens tested for compression and at least three (3) specimens tested for transverse strength comply with the requirements herein set forth, the said samples to be selected by a building inspector or by the laboratory from blocks actually going into construction work.

Hollow cement blocks must be subjected to the following tests: Transverse, compression and absorption, and may be subjected to the freezing and fire tests, but the expense of conducting the freezing and fire tests will not be imposed upon the manufacturer of said blocks.

The test samples must represent the ordinary commercial

product, of the regular size and shape used in construction. The samples may be tested as soon as desired by the applicant, but in no case later than sixty days after manufacture.

Transverse Test. The modulus of rupture for concrete blocks at twenty-eight days must average 150, and must not fall below 100 in any case.

Compression Test. The ultimate compressive strength at twenty-eight days must average one thousand (1,000) pounds per square inch, and must not fall below 700 in any case.

Absorption Test. The percentage of absorption (being the weight of water absorbed divided by the weight of the dry sample) must not average higher than 15 per cent., and must not exceed 22 per cent. in any case.

Any and all blocks, samples of which, on being tested under the direction of the bureau of building inspection, fail to stand at twenty-eight (28) days the tests required by this regulation, shall be marked " condemned " by the manufacturer or user and shall be destroyed.

Cement brick may be used as a substitute for clay brick. They shall be made of one part cement to not exceeding four parts clean sharp sand, or one part cement to not exceeding three parts clean sharp sand and three parts broken stone or gravel passing the ½-inch and refused by the ¼-inch mesh sieve. In all other respects, cement brick must conform to the requirements of the foregoing specifications.

Standard Method of Testing.

1. All tests required for approval shall be made in some laboratory of recognized standing, under the supervision of the engineer of the bureau of building inspection or the architect or engineer in charge, or all of these. The manufacturer may be present or represented during said tests, if he so desires. Approval tests are made at the expense of the applicant.

2. For the purposes of the tests, at least twelve (12) samples or test pieces must be provided. Such samples must represent the ordinary commercial product and may be selected from stock by the bureau of building inspection, or in the absence of such a bureau, by the architect or engineer in charge.

In cases where the material is made and used in special shapes or forms, too large for testing in the ordinary machines, smaller sized specimens shall be used as may be directed.

3. In addition to the tests required for approval, the weight per cubic foot of the material must also be obtained and recorded.

4. Tests shall be made in series of at least three (3), except that in the fire tests a series of two (four samples) are sufficient.

Transverse tests shall be made on full-sized samples. Half samples may be used for the crushing, freezing and fire tests. The remaining samples are kept in reserve, in case duplicate or confirmatory tests be required. All samples must be marked for identification and comparison.

5. The transverse test shall be made as follows: The samples shall be placed flatwise on two rounded knife edge bearings set parallel 7 inches apart. A load is then applied on top, midway between the supports, and transmitted through a similar rounded knife edge, until the sample is ruptured. The modulus of rupture shall then be determined by multiplying the total breaking load in pounds by 21 (three times the distance between supports in inches) and then dividing the result thus obtained by twice the product of the width in inches by the square of the depth in inches. $R = \frac{3\ W\ l}{2\ b\ d^2}$ No allowance should be made in figuring the modulus of the rupture for the hollow spaces.

6. The compression test shall be made as follows: Samples must be cut from blocks, so as to contain a full web section. The sample must be carefully measured, then bedded flatwise in plaster of paris, to secure a uniform bearing in the testing machine, and crushed. The total breaking load is then divided by the area in compression in square inches, no deduction to be made for hollow spaces; the area will be considered as the product of the width by the length.

7. The absorption test shall be made as follows: The sample is first thoroughly dried to a constant weight, at not to exceed 212° F. The weight must be carefully recorded. It is then placed in a pan or tray of water, face downward, immersing it to a depth of not less than 2 inches. It is again carefully weighed at the following periods: Thirty minutes, four hours, and forty-eight hours, respectively, from the time of immersion, being replaced in the water in each case as soon as the weight is taken. Its compressive strength, while still wet, is then determined at the end of the forty-eight hours period, in the manner specified in Section 6.

8. The freezing test shall be made as follows: The sample is immersed, as described in Section 7, for at least four hours, and then weighed. It is then placed in a freezing mixture or a refrigerator, or otherwise subjected to a temperature of less than 15° F. for at least twelve hours. It is then removed and placed

in water, where it must remain for at least one hour, the temperature of which is at least 150° F. This operation is repeated ten (10) times, after which the sample is again weighed while still wet from the last thawing. Its crushing strength should then be determined, as called for in Section 6.

9. The fire test is made as follows: Two samples are placed in a cold furnace in which the temperature is gradually raised to 1700° F. The test piece must be subjected to this temperature for at least thirty minutes. One of the samples is then plunged in cold water (about 50° to 60° F.) and the results noted. The second sample is permitted to cool gradually in air, and the results noted.

10. The following requirements must be met to secure an acceptance of the materials: The modulus of rupture for concrete blocks at twenty-eight days must average 150, and must not fall below 100 in any case. The ultimate compressive strength at twenty-eight days must average 1,000 pounds per square inch, and must not fall below 700 in any case. The percentage of absorption (being the weight of water absorbed divided by the weight of the dry sample) must not average higher than 15 per cent., and must not exceed 22 per cent. in any case. The reduction of compressive strength must not be more than 33⅓ per cent., except that when the lower figure is still above 1,000 pounds per square inch, the loss in strength may be neglected. The freezing and thawing process must not cause a loss in weight greater than 10 per cent., nor a loss in strength of more than 33⅓ per cent., except that when the lower figure is still above 1,000 pounds per square inch, the loss in strength may be neglected. The fire test must not cause the material to disintegrate.

E B Dawson

DEALER & JOBBER
IN GENERAL M'D'SE.
Boonton, N.J.

Mar 16th, 1907

The Frank E. Morse Co.,
17 State St, N. Y.

Dear Sirs:-

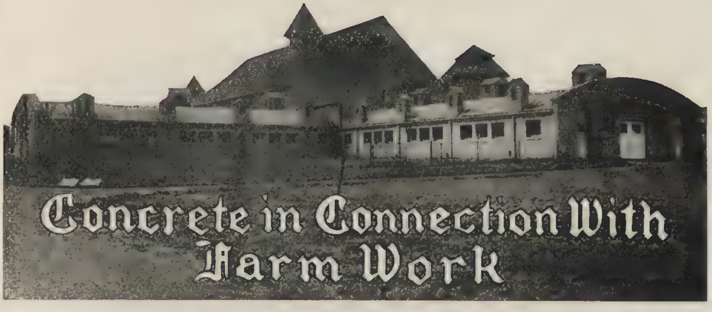
As you are aware, we have sold many thousand barrels of your DRAGON brand PORTLAND cement, all of which has given entire satisfaction.

We find our concrete workers, block makers and contractors give us the preference over other brands, claiming the DRAGON brand gives the best results.

Our City being a manufacturing town, we find for engine beds your DRAGON never fails to make the best foundations.

Yours truly,

E B Dawson



Concrete in Connection With Farm Work

The uses of cement in combination with gravel and sand are so numerous and the facility with which cement can be obtained and the large number of sand and gravel banks which occur, make its use particularly economical and advantageous. Almost every part of every construction on the farm can be and has been made of concrete either in mass or reinforced. Foundations are usually constructed by mixing cement, sand and gravel in the following proportions and depositing the mass after thoroughly mixing with the proper proportion of water, between wooden forms carefully laid out and staked to prevent their bulging during the process of depositing of concrete.

Materials for One Cubic Yard of Concrete.

*Proportions	Bbls. Cement in 1 cubic yard	Bbls. Sand in 1 cubic yard	Bbls. Gravel or Sand in 1 cubic yard
1:2:4	1.57	3.14	6.28
1:2½:5	1.29	3.23	6.45
1:3:6	1.10	3.30	6.60
1:4:8	0.85	3.40	6.80

For ordinary foundation work, mixtures in the proportions of 1:2½:5 or 1:3:6 are amply rich, but for pavements, floors, and building superstructures, mixtures in the proportion of 1:2:4 should be employed. Only very small quantities of gravel stones larger in diameter than 2½ to 3 inches should ever be employed even for mass concrete work and they should be mixed with smaller sizes down to grains of the size of peas. For super-

* In all of our proportions formulae, the first figure represents the quantity of cement; second figure, quantity of sand; and third figure, quantity of broken stone or gravel, all measurements to be by volume.

Reinforced Concrete Cow Barn at Gedney Farms, White Plains, N. Y.
Constructed of "Dragon" Portland Cement.

structural work in which steel is to be incorporated in the form of reinforcement, no pebbles larger than ¾″ should be used.

For the mixing of concrete materials by hand it is usually easiest to make batches which will contain only two or three bags of cement. Concrete is easiest mixed on a special platform. One of the cheapest of which can be made by nailing together ⅞″x10′ boards of any desired width with 2x4 cleats placed about 2′ apart. For a two-bag batch mixing platform should be 9′x10′, while for a four bag batch it should be 10′x12′. The aggregates are most easily measured by means of boxes built without tops or bottom and provided with four handles at the several corners, made by simply extending two sides and cutting them so that the hand can be easily placed beneath the extension of the sides and the mixing platform. For a 1:2:4 mix in which two bags of cement are to be employed, the sand box should be 2′x2′x 11½″ inside measurement, while the gravel or stone box should be 2′x4′x11½″.

For a 1:3:6 mix the sand box should be 2′x3′x11½″ and the stone gravel box 3′x4′x11½″.

For other combinations the necessary size of box is obvious from these measurements. The amount of water to be used varies slightly with the kind of cement and the qualities of sand and gravel. It may be roughly assumed that 10 gallons of water are necessary for a two bag batch mixed in proportions 1:2:4, while 13½ gallons will be necessary for a batch of similar size mixed 1:3:6. The methods of mixing concrete by hand, as to order of procedure, are almost as numerous as are the individuals who do the work; but the following method has been found easy and effective: Place the sand box on the mixing board and fill it with sand from wheelbarrows or by other convenient methods. When the box is filled level full lift it off and spread the sand on the board in a layer about 4″ thick. Empty the required number of bags of cement over the sand as evenly as possible; mix the sand and cement by turning it over with shovels into a new pile of the same general shape and thickness as the old one, giving the shovel a smart twist just before the material leaves it, so as to mix the sand and cement thoroughly. Two or three operations of this nature may be required, the material being shoveled from one side of the board to the other with each turn. After a sufficient number of operations and spreadings of this nature have been carried out it should produce a perfect mixture, place the gravel or stone box on top of the pile of sand and cement, and fill it from wheelbarrows or other receptacles as

Interior of Cow Barn, Gedney Farms, White Plains, N. Y.
"Dragon" Portland Cement Used.

before. Remove the box and pour over the top of the gravel and stone about three-fourths of the required amount of water, dashing it over the top of the pile as evenly as possible. Do not lose any of the water by letting it run off the edges of the board. Again turn the whole material over in the same manner as with the sand and cement, adding water little by little to the dry spots as the mixing continues. Repeat this operation until the whole mass is uniform in color and moisture.

A concrete which quakes like jelly when being handled and is just too stiff to flow is right for most purposes, like foundations, sidewalks, etc. For building work, ornamental and other complicated pieces, a very wet concrete is usually employed, while occasionally a relatively dry mixture, which must afterward be sprinkled several times a day for several weeks is preferable.

The concrete is then ready to be placed. It can be conveyed to the desired point of deposit most easily by wheelbarrows, unless it is found necessary to place the mixing board more than 100′ from this pont, in which case an ordinary one-horse dump cart will be found convenient. If wheelbarrows are employed, runways of 2″ plank about 12″ wide should be laid down and carefully maintained so that wheelbarrows do not run off the edges and upset so as to lose their contents. The runway should be laid out in the form of a circuit so that men do not meet each other on the return and thus interfere with one another.

Foundations for barns, silos, green houses, cellars, ice houses, chicken houses, etc., are easily constructed and where the earth will stand without special bracing, the concrete may be deposited in open trenches at a very small cost.

An ordinary carpenter can build the necessary forms for water tanks, cisterns, watering troughs, partitions in root cellars and other similar structures, and concrete mixed as above described, can be readily deposited in them. Mass concrete can also be used for culverts under roadways for carrying the water from small streams.

It is also an easy matter to make open boxes either straight or tapered in which concrete can be deposited together with the necessary wire for reinforcing the same so as to form fence posts, clothes posts, blocks of artificial stone for horse blocks, for window sills, steps, hog troughs, retaining walls, curbs, steps, etc. Tests of fence posts made in this way, designed to extend four feet above the ground, showed that it would require a pull of about 500 pounds applied at the top of the post to break it if it is made 6″x6″ at the bottom and 6″x3″ at the top, and if four

Reinforced Concrete Fence and Barns at Gedney Farms, White Plains, N. Y.

ordinary twisted fence wires were placed near the corners in the wet concrete. By pushing loops of wire into the wet concrete at proper intervals along the post, very convenient fastenings are provided for the attachment of the common wire fencing. More elaborate structures like chicken houses, piggeries, ice houses, mushroon cellars, green houses, silos, duck houses, manure sheds, and even the most elaborate farm buildings like stables, can be built of reinforced concrete in as elaborate detail as is desired. Such complicated things as chimneys have been built of reinforced concrete on the farm, while at the other extreme the simple laying of sidewalks and floors in stables and cow barns, feeding floors, etc., can be easily constructed in concrete. To do the latter work, the ground should be excavated at least 12″ below grade and refilled with porous material like coal cinders or gravel, to a depth of 8″. This material should be thoroughly compacted after careful wetting, so that the final thickness is about 7″. This excavation and refill should be so arranged that water which may collect in it will be drained naturally away from the structure. This drainage can be effected by actual drain tile, either of terra cotta or cement pipe, or by the use of a blind drain made of broken brick or large gravel. Upon this sub-base is to be deposited a mass of concrete which when finally compacted will have a thickness of 4″. This concrete should be mixed in the proportions of 1:2½:5 and before it is set, a top coat of cement mortar mixed in proportions of 1 cement to 2 coarse sand should be spread upon this concrete base and thoroughly worked into contact with it by much trowelling. This wearing surface should have a thickness of at least 1″ and its top surface be carefully leveled and smoothed and finally marked in blocks either 4′ square or of smaller size as is deemed necessary for the particular object in view. For sidewalks or cellar floors blocks not more than about 4′ square are wisest, while in stables and at other similar points, where much traffic is to be encountered, squares as small as 6″x6″ are best. The larger blocks should be cut clear through the 4″ concrete base, and surfaces which are marked in small blocks should be similarly cut through at about the same intervals.

Concrete is indispensable in dairy farming since Boards of Health in cities throughout the United States and Europe are demanding high sanitary conditions in dairies which can be secured most economically only where concrete is used for the construction of cow stables, feeding floors, etc. Dairy farmers also find other economies obtainable with the use of concrete, aside

PORTAL OF DIVERSION TUNNEL, FILTRATION PLANT, ALTOONA, PA.
"DRAGON" PORTLAND CEMENT USED EXCLUSIVELY.

from the advantages secured with regard to sanitation when proper gutters and drains are provided, the stables can be completely flushed out with water and a disinfectant if necessary although the very nature of the concrete materials makes them practically germ proof when made in a dense workmanlike manner.

Similarly, poultry houses and yards can be maintained in a high sanitary condition where concrete is employed, and the latest developments along this line even provide cement hens' nests and runways. The feeding and scratching floors can advantageously be constructed with concrete covered with 6″ or more of clean gravel, sand crushed shells, etc., which can be replaced from time to time as deemed necessary.

Garbage receptacles, either in the form of permanent boxes or in the shape of light cans are being manufactured of concrete which are fire and vermin proof, and when properly waterproofed are not subject to attack by rust or other disintegrating influences.

Non-destructible and explosion proof gasoline, wood alcohol and kerosene tanks can be constructed with great advantage.

The ornamental possibilities of concrete are very great, especially when reinforced. Molded fountains of cement concrete can be erected of the most complicated and beautiful sort. The basin can be made of any shape and lined with a mixture of 1 cement to 2 sand applied as described above for top surfacing of sidewalks and floors, but this surface, however, should not be cut into blocks as there described. The mass concrete of the basin should have provided in it some reinforcement to prevent cracks due to freezing and thawing, from winter to summer. This reinforcement, however, need not be very great in quantity, but should be well distributed throughout the whole body.

Settees or benches of reinforced concrete can be readily constructed as complicated and artistic as desired, while some crude products, which would be equally as serviceable, can be made of mass concrete at much less expense.

Besides the posts for fences, the running members can be made of concrete, molded separately and placed in position in the forms before the concrete for the posts is deposited in the final positions they are to occupy. If deemed preferable even these posts can be molded on the side in special forms with recesses formed in the concrete work by placing blocks at the necessary points on the sides of the forms. These recesses will serve to receive the ends of the running members of the fence and it is necessary only to

tamp a post in position, set in place the strings between it and the next one, propping them so that the next post can be put in place, and then tamping it firmly on the ground. It is often preferable under those circumstances to place a small amount of concrete in the post hole instead of refilling it solely with earth. A fence made of this description is absolutely indestructible, needs no painting, will not be affected by attacks of burrowing insects, and stock and small animals will not gnaw it or otherwise destroy it.

Cement bath tubs have been manufactured and placed in houses and are cheap and effective.

Tree Dentistry.

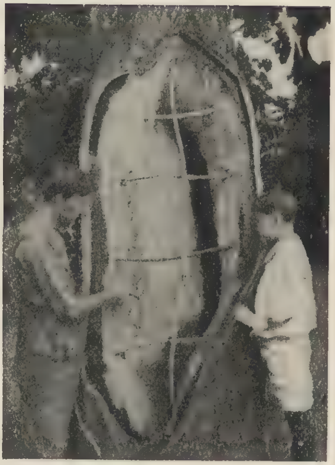
(Cuts furnished through courtesy of The Davey Tree Expert Company)

Conservation of natural resources is claiming public attention from the Chief Executive to the smallest landowner. Trees are almost a necessity of modern life, but their neglect has been a crying shame in this country for many years. With the advent of Portland Cement a new art in connection with the science of forestry has developed, namely that of "tree dentistry," so-called.

Nature uses every effort to correct the destruction to her trees wrought by winds, heavy snows, boring insects and animals and the insidious effects of decay. Limbs are split by the wind and snow, water enters the crevices and decay almost immediately follows, enlarging the cavity until finally another storm produces the ultimate destruction of the one time giant of the forest. By the practical attention of a skilled forester, cases in which destruction is imminent can be completely saved and given a length of life which is practically unending. Nature assists, but cement and surgery are necessary preliminaries.

It is necessary first to correct the tendency to split (if such has been the cause of the trouble), and by the proper installation of chains any further trouble can be obviated. It is next essential that every particle of decayed material be removed from the interior of a rotting limb or trunk; next, a steel brace may be required to strengthen the tree and re-establish the stability of which the decay had robbed the tree. The interior of the cavity should then be studded with nails or similar devices to afford a close bond between the filling and the firm wood, and further reinforcement in the form of bars, wires or wire mesh should be carefully installed to reinforce the concrete to be used for filling. Even after the cavity has been packed with concrete, unless this work is carefully done, the swaying of the tree by the wind will be apt to separate the cement from the wood so that a narrow crevice is formed, into which moisture will percolate and the decay continue even worse than before. Expert workmen, therefore, prepare special "water sheds," or deep grooves, installed around and just within the opening, so as to let out to the ground all incoming moisture. The cement is installed in a very moist condition and carefully built out into the original outline of the

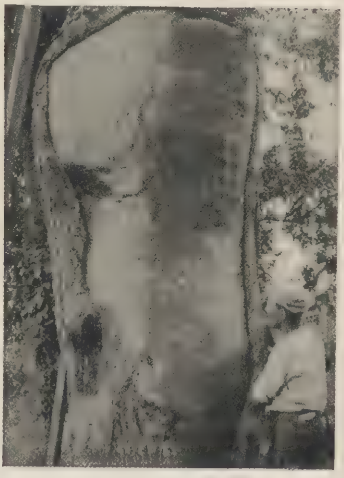
BEFORE TREATMENT



METHOD OF TREATMENT

SAVING THE TREES

SEVERAL YEARS AFTER TREATMENT



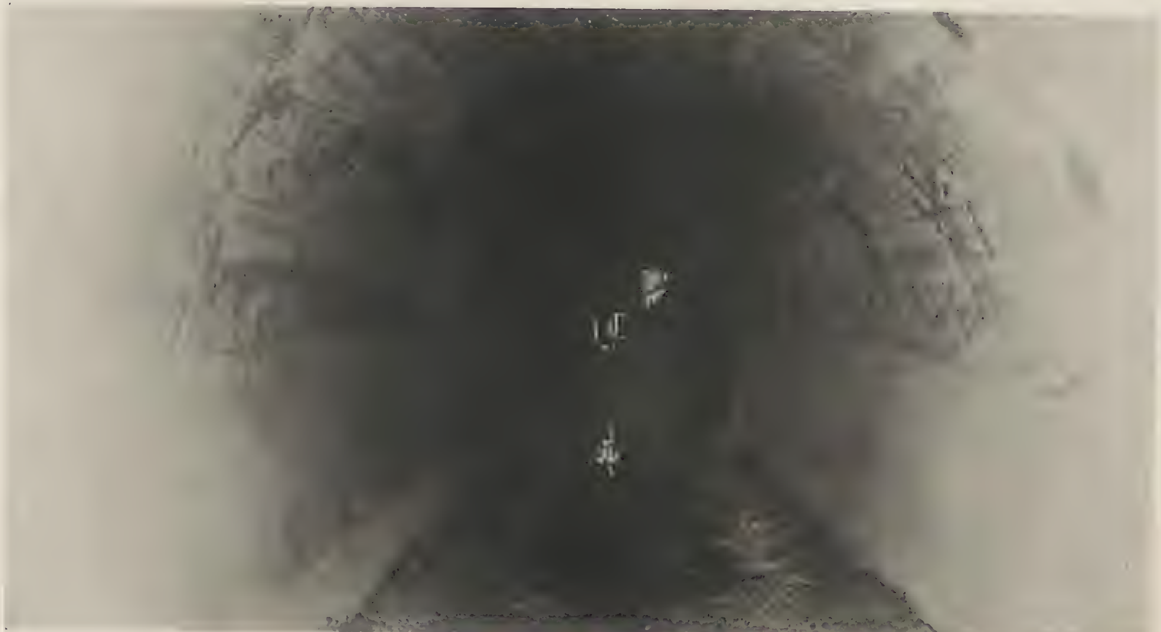
LARGE CAVITY FILLED

tree. This work must be made particularly dense so as to exclude all water, since otherwise the filling is worse than useless. No porous or undrained spot should be allowed.

The bark has to be carefully cut back for an inch or so in order to prevent bruising it while the work is in progress, but it can be replaced and will eventually cover the wound in the side of the tree through natural agencies. If properly replaced, the tree will thus regain its normal appearance, the outside completely surrounding the concrete filling of a one time deadly cavity.

Where cavities are of an exceptional size, a form consisting of strips of metal is first installed, and the concrete is forced down into every crevice and allowed to set. The forms are afterwards removed and a coat of surface finish installed. By this method, the forester is enabled to build out trees in which fully one-half the wood may have been destroyed by lightning or other cause. The concrete is usually finally painted the same color as the bark of the tree so that the original defect is entirely unnoticeable.

Through the evolution of this form of treatment, " DRAGON " Portland Cement is thus seen to be essential for the preservation of the beauty and life of much of the vegetation of this continent.

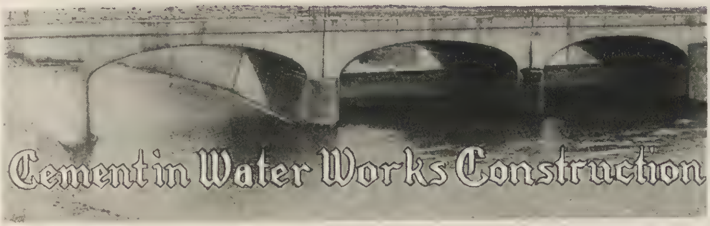


Interior of Diversion Tunnel, Filtration Plant, Altoona, Pa.
"Dragon" Portland Cement Used Exclusively.

End of Diversion Tunnel, Filtration Plant,
Altoona, Pa.
"Dragon" Portland Cement Used Exclusively.

Reinforced Concrete Arch Bridge Carrying Roadway Over By Pass, Filtration Plant, Altoona, Pa.

"Dragon" Portland Cement Used Exclusively.



The reproductions on pages 122, 128, 129, 130 and 132 show some of the details of the work done on the Filtration Plant at Altoona on which Dragon Portland Cement was used exclusively to the extent of over 22,000 barrels. The picture on page 122 shows an end view of the diversion tunnel. This tunnel is 1200 feet long and 9 feet in diameter and is used to carry off the surplus water. Note the warped surfaces in the concrete walls just outside of the tunnel.

The picture on page 129 shows the lower end of this tunnel. It looks somewhat small in the picture but this is due to the fact that the photographer had to stand his camera some distance from the exit because water was six or eight feet deep where he should have been located.

The picture on page 130 shows the reinforced concrete arch bridge which carries the road-way over the by-pass. The picture on page 132 shows this by-pass as it makes a bend in the hill. This structure is 15 feet wide on the inside and 5 feet deep, the concrete walls being 2½ feet thick.

The illustration on page 134 shows the reservoir under construction for the Oil City Waterworks in Pennsylvania. The small size of the mixing plant is to be noted and the methods of handling concrete in wheelbarrows and down chutes. The aggregates are wheeled up the inclines and dumped from the wheelbarrows into the portable mixers.

Note the reinforcement for the bottom and sides of the reservoir and how the inner surface is finished in blocks. Reinforcing rods are seen projecting above the surfaces where the columns to support the roof are to be erected.

This illustration is typical of the best class of work of reservoir construction. In large numbers of such structures Dragon Cement has been successfully employed.

By Pass, Filtration Plant, Altoona, Pa.
"Dragon" Portland Cement Used Exclusively.

The Torresdale Preliminary Filters of the Philadelphia Water Works.

Abstract from Engineering Record, Nov. 14, 1908.

The City of Philadelphia has now under construction alongside its slow-sand filtration plant at Torresdale, a system of mechanical filters, which will be used as roughing filters, without the use of a coagulant, to take out the larger suspended particles from the water before applying it to the slow-sand beds. At present, the latter plant, at a rate of 3,000,000 gallons per acre per day, has a total capacity of 120,000,000 gallons. With the operation of the preliminary filters it is expected that this rate will be doubled, and therefore the preliminary plant is designed for a total capacity of 240,000,000 gallons per day at a rate of 80,000,000 gallons per acre. The new plant has the distinction of being the first in the United States for the double filtration of the supply of a large city and at the same time of being the largest of mechanical filter plants.

The preliminary filters in general are of the usual mechanical type, using both water and air in washing, but omitting the coagulant. They are placed high enough so that their effluents will pass through the sand-beds by gravity.

The area covered by the preliminary filters themselves, exclusive of the driveways and embankments, measures 328 ft. 9 in. by 607 ft., and contains 120 beds, arranged in eight rows or batteries, with 15 beds to a battery. There are four filter houses, each running across the width of the entire plant and controlling two batteries or 30 beds. Each bed measures 20 ft. 3 in. by 60 ft. in the clear and is controlled by its individual operating table. The influent is admitted over a reinforced concrete wash-water trough or gullet in the wall at the rear of the bed, and drains to an effluent gullet or to a wash-water drain in the filter house.

The floors, walls and roofs are in general constructed of concrete, reinforced where necessary and supported in places by structural steel shapes. The walls of the filter houses are of brick faced both inside and outside, and trimmed with gray

Reservoir of Oil City Water Works, Oil City, Pa
"Dragon" Portland Cement Used Exclusively.

granite. The walls of the filter beds vary in thickness from 15 to 21 inches and are reinforced for carrying a water load on either side, while the other side is empty. The roof over the filter beds is a 6 in. reinforced concrete slab carried by 18 in. 60 ℔. I-beams on 7 ft. centers, completely incased in concrete and spanning the width of the beds, a distance of 22 ft. center to center of the transverse walls. Seven 3 ft. manholes have been placed in the roof over each bed, six of them being placed in two rows of three each, and the seventh directly over the valve which admits the raw water from the influent gullet. The concrete roof slab has a covering 16 in. deep, composed of 2 in. of broken stone or clean gravel, 10 in. of sandy material and 4 in. of top soil. Roof drains of 4 in. terra cotta pipe are placed at convenient intervals and are covered with a 9 in. mound of broken stone. The manholes rise 6 in. above the top of the covering and have, in addition to the covers, screens allowing the ventilation of the beds. Electric lights are placed in all of the beds and are hung from insulators on rods cast into the concrete of the roof.

The raw water is pumped to the preliminary filter plant from the pumping station on the river bank through an 11 ft. riveted steel conduit covered with a minimum thickness of 6 in. of concrete. This conduit runs almost the full length of the filter plant and is tapped at three points by 7 ft. riveted steel conduits and at two points by 5 ft. 6 in. steel conduits leading to the five influent gullets. These influent gullets each run the full width of the plant, or 328 ft. 9 in., and serve one or two batteries of beds. They are formed by the longitudinal walls at the backs of the beds of adjacent batteries, except the gullets at the ends of the plant, which have one wall forming the extreme edge of the plant. They are roofed with a 6 in. reinforced concrete slab carried by concrete brackets extending out 8 in. from the vertical walls of the gullet.

The raw water finds admittance to the filter beds from the influent gullet through a cast iron pipe controlled by a 16 in. hydraulically operated valve, located in an enlargement at the end of the wash-water gullet.

The filtering material consists of 15 in. of gravel varying in size from 2 to 3 in., 4 in. of gravel varying from ⅝ to 1½ in., 3 in. of gravel varying from ¼ to ½ in., 8 in. of gravel varying from ⅛ to ¼ in., and 12 in. of sand varying from 0.8 to 1mm. The water surface will be 4 ft. above the top of the sand. The filtered water will be carried off by two collectors, extending

Water Tower at Pie Filter, Torresdale Filtration Plant, Philadelphia, Pa.
"Dragon" Portland Cement Used Exclusively.

the length of the bed. These collectors are built of reinforced concrete moulded in 2 ft. slabs at convenient points and placed in the beds when the concrete has fully set. The collectors are of rectangular section, 30 in. wide inside and 8 in. deep, forming an inverted longitudinal box resting on the floor of the filter bed. The sides and top are 4 in. thick, making an overall width of 3 ft. 2 in. Openings are cast in the collector slabs by cutting away part of the walls just at floor level. The two collectors in each bed connect together at the end near the filter house, where a 16 in. pipe draws off the water. After passing through a hydraulically operated valve and the effluent controller, it passes into the effluent gullet, which is a reinforced concrete rectangular box built the full length, and on the floor, of the filter house. It is 6 ft. wide and 6 ft. high, with 12 in. walls and 6 in. top. The 30 in. cast-iron wash-water supply main is laid directly upon the effluent gullet.

The presssure for the water-wash system will be secured from an elevated reinforced concrete tank located east of the plant. The tank contains two separate compartments, one for wash-water, and one for filtered water for drinking and sanitary purposes. The tanks themselves occupy the upper part of the tower, the floors being at an elevation of 27 ft. above the filled embankment surrounding the filter plant. The tank walls are of reinforced concrete and the floor of concrete slabs, supported by 15 in. 42 lb. I-beams. The filtered water tank occupies the central part of the tower and is 12 ft. in diameter in the clear. The wash-water tank is an annular ring surrounding the filtered water tank. The walls of both the filtered and wash-water tanks are carried down vertically through plain concrete walls to 6 ft. concrete footings going down below the original surface of the ground. A 48 in. wash-water and a 6 in. filtered water pipe lead from the tank to the filter plant. The extreme inside diameter of the tank is 40 ft., the height above the rolled embankment 70 ft., and the height above the bottom of the footings 91 ft.

Wherever possible in the work the conveying of materials and the handling of heavy loads were done by derricks or by an 850 ft. span Lidgerwood cableway. This cableway spanned the entire work from north to south and was fitted with an engine on the tail tower to facilitate moving the entire apparatus east and west, so that the cableway carriage could cover any part of the plant. The cableway was used for placing concrete, for moving forms, placing I-beams, and for any work where it could

FOUNDATIONS FOR FILTER BEDS, TORRESDALE FILTRATION PLANT, PHILADELPHIA, PA.
"DRAGON" PORTLAND CEMENT USED EXCLUSIVELY.

be used to advantage without interfering with the operations for which it was expressly intended.

The aggregate used in the concrete consisted half of gravel and half of broken stone, the latter of a maximum size of 1½ in., except where thinness of walls and close spacing of reinforcement necessitated smaller stone. "Dragon" Portland cement was used throughout. The reinforcement used in the work consisted of plain square bars.

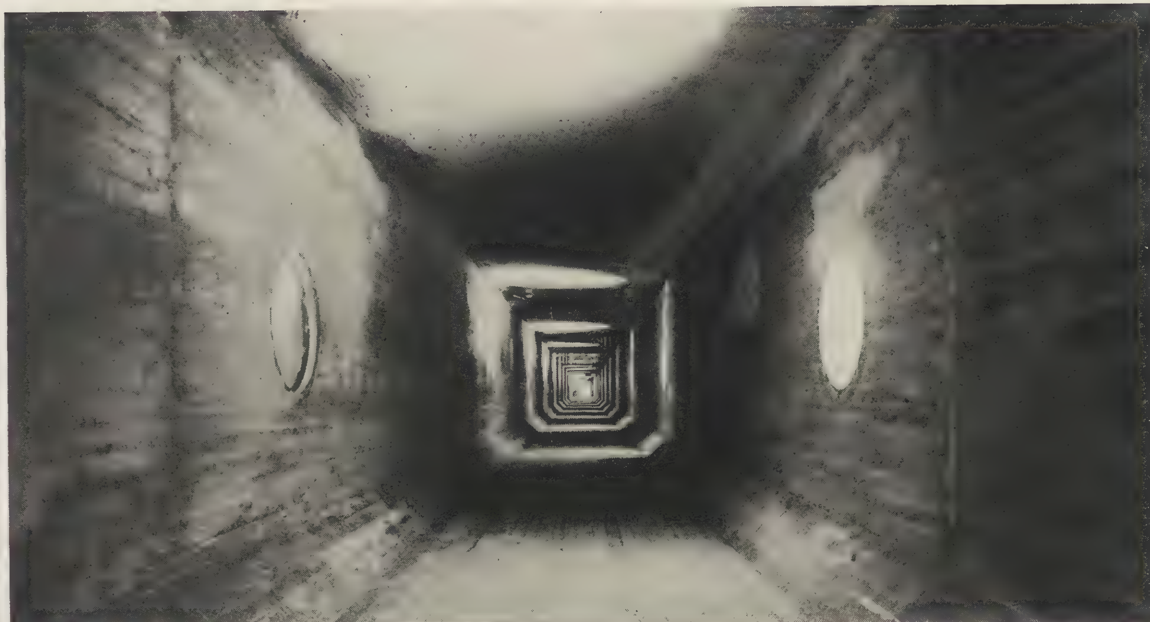
In addition to the main mixing plant at the southwest corner of the work, a ½ yd. portably mounted McKelvey mixer was used to place some of the concrete along the east side of the plant, and a ½ yd. Ransome mixer was used on the elevated water tank by the sub-contractors for that work.

The largest forms for the concrete work were 12 ft. wide and 10½ ft. high. All forms were stoutly made and held together by studs and 6x8 in. walls placed 4 ft. apart. The bolts passing through the walls to hold the forms against bulging were placed 4 ft. each way and run through these walls. This stout construction was adopted because the concrete was deposited continuously in the walls, lengths as short as 60 ft. being put in in one continuous operation, starting at one end and filling up to a certain level clear across to the other end and then starting back immediately toward the point of beginning.

The handling of the forms wherever possible was done by the cableway and by a stiff-leg derrick mounted on a traveling platform. The forms for the influent gullet were gathered together in groups of three, hoisted out by the cableway and moved to their new positions. The wall forms were moved by the stiff-leg derrick, and the roof forms were moved by hand.

The 11 ft. riveted steel pipe lines for the influent and effluent were laid with a derrick traveling on the floor of the trench in which the conduits were placed. This trench was excavated with an orange peel bucket hung from a locomotive crane. The pipe was riveted up in place by compressed air.

The general contractor for the work is the Millard Construction Co., of Philadelphia.



Conduit on Pie Filter, Torresdale, Philadelphia, Pa.
"Dragon" Portland Cement Used Exclusively.

Saml P. White, President
J. F. Mitchell, Sec'y & Treas.

T. P. White, M. A. S. C. E., Vice President & Chief Engineer
C. M. Emmons, M. A. S. C. E., Assistant Engineer
ESTABLISHED 1868

C. H. Vaughan, M. A. S. C. E., Construction Engineer
R. J. Kier, Superintendent Shops

AGREEMENTS ARE CONTINGENT UPON STRIKES, DELAYS OF MILLS AND CARRIERS OR OTHER CAUSES BEYOND OUR CONTROL

Penn Bridge Company,
Beaver Falls, Pa.

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Bridges & Structural Material.

WILLIAM FARRIS, CONTRACTING AGENT
THOS. F. HUNGIVILLE, ASSISTANT

203-4 DIAMOND BANK BUILDING.
Pittsburgh, Pa.

November 30, 1908.

Cumb. Hydraulic Cement & Mfg. Co.,
Cumberland, Maryland

Gentlemen:-

We have your inquiry of Nov 10, 1908, asking for our experience with Dragon Portland Cement in Bridge Construction.

We used Dragon cement exclusively in theVirginia Street Bridge over Elk River, Charleston, W. Va. in the concrete piers and abutments as well as in the reinforced concrete walks.

No cement ever gave us better satisfaction. It has good sand carrying capacity, sets up slowly and very hard, and shows even color at the finish.

Yours very truly,

PENN BRIDGE COMPANY.

By

William Farris.

Large Steel Concrete Covered Pipe Carrying Water from Intake to Pie Filters,
Torresdale Filtration Plant, Philadelphia, Pa.
"Dragon" Portland Cement Used Exclusively.

The American Pipe Manufacturing Company
Engineers and Contractors Water Works a Specialty

James H. Dawes,
Gen'l Sup't of Construction

Office 112 North Broad Street.
Philadelphia.

Subject:

Nov 27, 1908.

Lawrence Cement Co.,
Philadelphia.

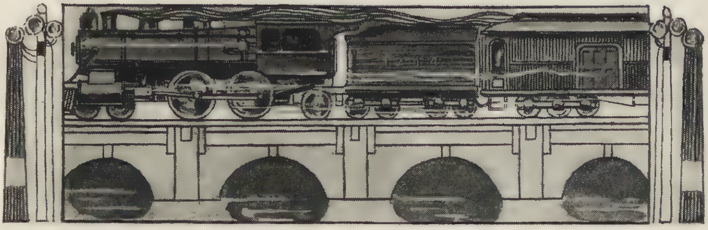
Gentlemen:-

In reply to your recent favor in regard to the use of "Dragon" Portland Cement on our work, we wish to say that we have used a large quantity of this cement in the construction of various reservoirs and dams, and have had thoroughly satisfactory results in each case. We consider the "Dragon" Cement one of the best cements on the market for use in our hydraulic work.

Yours very truly,

James H. Dawes

Abutments on Line of Pennsylvania Railroad's New Line Across Hackensack Meadows, to Connect With Tunnels Through New York City.



Cement in Railroad Construction

The following descriptions will serve as examples of the various ways in which " DRAGON " cement has been employed by the forty-five railroads which have used it.

The illustration on page 144 shows some of the work involved by the new line of the Pennsylvania Railroad across the Hackensack Meadows to connect the present main line with their tunnels under the North and East Rivers and their new station in Manhattan, New York City. " DRAGON " cement was used throughout for bridge piers, abutments, etc., on this work.

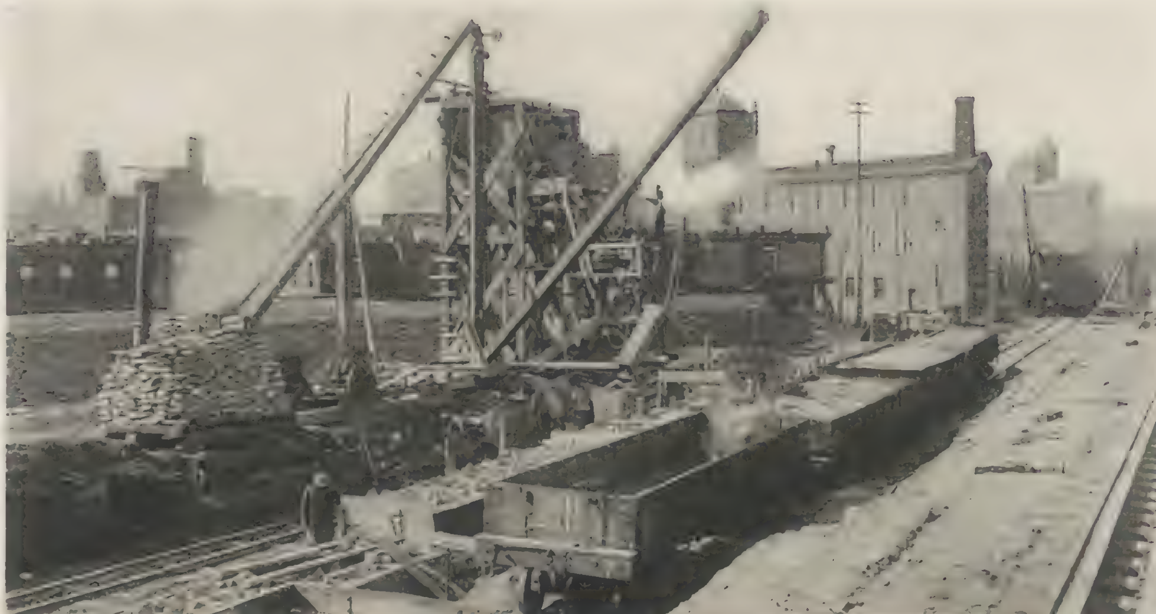
Note the traveling frames against which forms were erected for the construction of this bridge pier. These forms were moved along from section to section of the wall and were so designed as to occupy only the small space between the finished wall and the railroad tracks over which traffc was constantly maintained.

Note also the concrete handling plant consisting of stiff-leg derricks handling automatic dump buckets for the concrete and the grab bucket employed to hoist concrete aggregates from scows and deposit the same in the hoppers over the concrete mixer.

Note also the hanging scaffold employed in connection with the finishing of the concrete work on the face of the abutment.

The reproduction shown on page 146 is a small section of the track elevation work being done in Philadelphia along the line of the Philadelphia & Reading Railroad. The total length of track elevation covers a distance of six miles and it is estimated that about 250,000 barrels of Dragon cement will be used. At its highest point the retaining wall is 35 feet from the foundation masonry to the top of the coping. The width at the bottom is 7 feet and at the top is 3 feet.

Note the method of bonding old and new work by depositing



Work on Line of Philadelphia & Reading R. R. Co.'s Track Elevation Between Wayne Junction and Reading Terminal, Philadelphia, Pa.

THE LITTLE KANAWHA RAILROAD COMPANY.
MARIETTA, COLUMBUS & CLEVELAND R. R. CO.
BUCKHANNON AND NORTHERN RAILROAD COMPANY.
ZANESVILLE, MARIETTA & PARKERSBURG RAILROAD CO.
PARKERSBURG BRIDGE & TERMINAL RAILROAD CO.
BURNSVILLE AND EASTERN R. R. CO.
CHIEF ENGINEER'S OFFICE.
GUARANTY BUILDING.

PARKERSBURG, W. VA.,

July 7, 1906.

The Cumberland Hydraulic
Cement and Mnfg Co.,
Cumberland, Md.

Gentlemen:-

We have used your "Dragon" Portland cement for the last five years on our lines, and it has given perfect satisfaction. We have used it in extreme cold weather and was surprised at the good results. I remain

Yours very truly,

David T. Brady

Chief Engineer.

Bridge Pier on Philadelphia & Reading Railway Track Elevation, Philadelphia, Pa.

large stones irregularly in the fresh concrete where they are allowed to become firmly imbedded, projecting irregularly above the upper surface of the mass concrete.

Note the method of mixing concrete wherein overhead bins feed the mixer, the product of which was handled either by stiff-leg derricks or traveling cranes running on the tracks parallel with the line of the wall.

Note the derrick equipped with a grab bucket employed to remove material from cars and hoist the concrete aggregate into the hoppers over the mixer.

Page 148 shows another view of the same work. Of particular interest in this picture are the deep grooves cast in the end of the wall into which will fit a corresponding projection in the next section so that unequal settlement will not throw the wall out of line, the loose stone piled against the back of the wall to provide ample drainage, and the narrow grooves cast in the face of the wall to resemble courses of masonry. A scaffold was erected in front of the wall on which the men could work to grout, rub and otherwise finish the surface.

THE CONNECTICUT AVENUE BRIDGE AT WASHINGTON, D. C.
"DRAGON" PORTLAND CEMENT USED EXCLUSIVELY.

The Connecticut Avenue Concrete Arch Bridge at Washington, D. C.

Abstracted from Engineering News, June 1, 1905.

The Connecticut Avenue Bridge at Washington, D. C., is notable in two particulars; it is one of the largest masonry arch bridges ever constructed, and it is built of a combination of molded concrete block and monolithic concrete masonry which is exceedingly rare.

The site of the bridge being conspicuous topographically, great effort was warranted to have it comport in proportions, type and style, with the dignity of the thoroughfare of which it was a part.

The structure consists of seven full centered arches carried by two abutments and six piers. Piers 37 feet thick separate the end arches from the wider intermediate arches, and the intermediate arches are separated from each other by piers 20 feet thick. The total length of the bridge, including abutments is 1,341 feet. Its width between faces of arch rings is 52 feet. The 150 foot arches support open transverse spandrel arches. The end arches support transverse spandrel arches which are closed by face walls, so that they appear as having solid spandrel walls. The abutments are hollow U-shaped with walls having vertical faces and stepped backs. The backs of the walls are water-proofed with two coats of coal-tar pitch of the grade known as paving cement. Aside from the water-proofing the only structural detail at all unusual was the expansion joint construction adopted for the side walls.

These walls are about 135 feet long and each has two vertical expansion joints reaching from the foundation to the floor level of the bridge. The key groove does not extend to the top of the wall, which, being but 4 feet thick, was considered too thin to permit safely of its use. Instead of a mortise and tenon joint, this top wall section has a plain butt joint with steel rods extending across it to hold the abutting walls together. The puddle groove or mortise reaches, however, from top to bottom of the wall. The object of the clay puddle is to prevent seepage of water through the expansion joint. These expansion joints

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Portland Cement
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Portland Cement
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Cement
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Metal Lath, Wall Ties
SAND AND GRAVEL
Machine Made Mortar

Washington, D. C.,

June 15th, 1907.

The Lawrence Cement Co.,
New York City

Gentlemen:-

Within the past four or five years, we have bought from you and sold to our customers, nearly ONE MILLION barrels of "Dragon" Portland cement, and it is a pleasure for us to be able to truthfully state that notwithstanding the fact that we have placed it on work of all kinds and character, it has given entire satisfaction in each and every instance. A large portion of the "Dragon" we have bought from you has been used on the General and Washington City Government works, where the requirements and tests have been unusually rigid, but "Dragon" has always met them satisfactorily. We sold to the Contractors for use in the construction of the Connecticut Avenue Bridge (which is probably the largest all-concrete bridge in the world) over eighty thousand barrels of "Dragon". We also furnished "Dragon" to the Contractors for laying the cement sidewalks for the City Government during the years 1905 and 1906.

Space will not permit us to enumerate all of the important government and private works upon which we have furnished "Dragon." After having had such satisfactory experience in handling "Dragon" during such a long period, there can be no wonder that we do not hesitate to tell our customers that if they want a first-class Portland cement on their work, they "can't hitch Dragon up wrong."

Yours very truly,

NATIONAL MORTAR CO.,

OWNER.

worked perfectly. In the coldest days of winter they open about 3-16 inch, and in the summer close to 1-16 inch.

The piers are solid concrete structures to the springing line levels of the arches and of cellular construction from there to the top, which is covered by an arch.

There are seven arch spans, two of 82 feet span and five of 150 feet span. The rings of these arches are monolithic concrete with faces of voussoir shaped molded concrete blocks. For the 82 foot arches the crown thickness of the ring is 3 feet 3 inches and for the 150 foot arches it is 5 feet. There is no reinforcement.

The spandrels of the main arches were composed of relieving or spandrel arches the tops of which carry the roadway. Over the 82 foot spans, a solid spandrel curtain wall incloses the arches and gives the aspect of solid spandrel construction. The arches over the piers were also similarly inclosed, but those over the haunches were designed with a vertical expansion joint at the crown of each. Since these crown expansion joints will, if they open much, convert the opposite valves of the arches into cantilevers, the rings are reinforced. The roadway was provided by a solid fill over the spandrel arches.

About 50,000 cubic yards of concrete were required for the construction of the bridge. The stone for this concrete was a diorite obtained from a quarry opened in the side of the bluff about 500 feet from the south end of the bridge. The stone from the quarry was hoisted about 50 feet vertically by derricks and dumped into cars which traveled on an incline about 250 feet to a No. 4 Gates gyratory stone crusher into which they dumped automatically. From the crusher the stone dropped into a 600 cubic yard bin under the bottom of which and beneath the ground was a tunnel large enough for a dump car. This car was handled by cable to the storage bins of a Haines gravity concrete mixer. The sand was brought to the work in wagons and dumped in a pile on a platform about 50 feet above the bottom level of the broken stone bin. A tunnel similar to that for the stone bin and about 40 feet from the stone car tunnel was provided for the sand car which was hauled to the mixer by the same cable that hauled the stone car, the cable being shifted by hand as desired. Cement was delivered to the mixer by means of a bag chute from the top of the gorge adjacent to the mixer.

After passing the mixer the concrete dropped into a skip or bucket mounted on a car which ran on a trestle erected the full

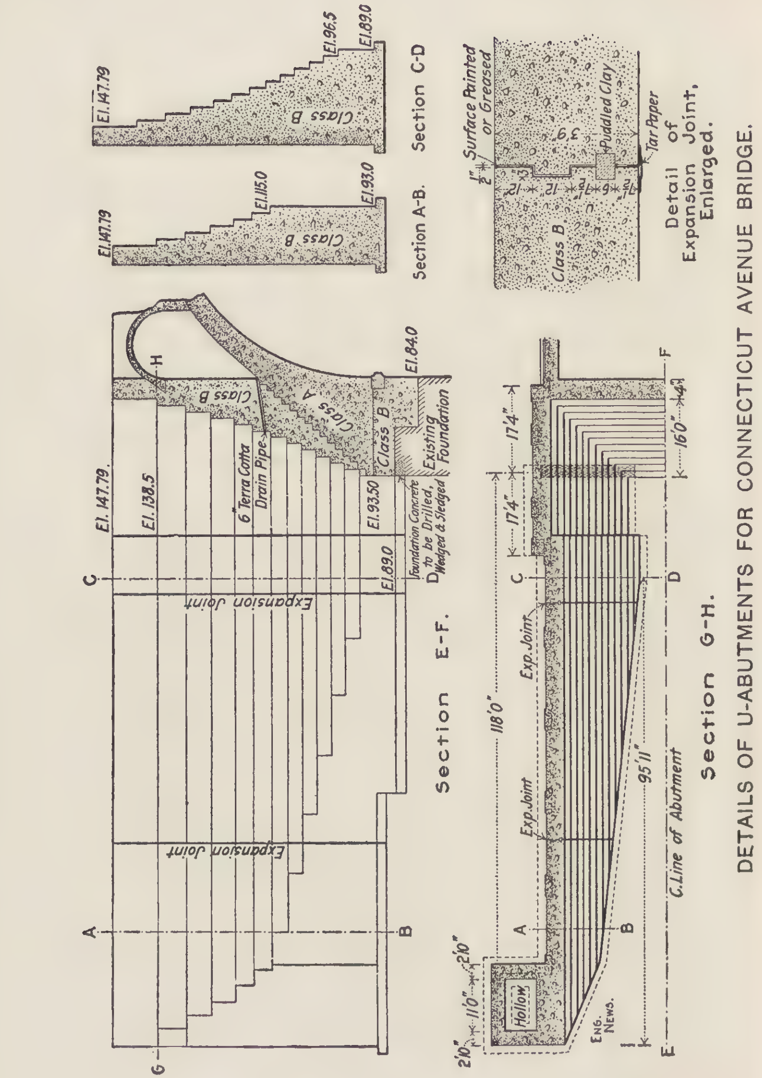

DETAILS OF U-ABUTMENTS FOR CONNECTICUT AVENUE BRIDGE.
Section E-F.
Section G-H.
Section A-B.
Section C-D
Detail of Expansion Joint, Enlarged.
El. 147.79
El. 138.5
El. 93.50
El. 89.0
El. 84.0
El. 115.0
El. 93.0
El. 96.5
Class A
Class B
Expansion Joint
Exp. Joint
6" Terra Cotta Drain Pipe
Foundation Concrete to be Drilled, Wedged & Sledged
Existing Foundation
Surface Painted or Greased
Puddled Clay
Tar Paper
Hollow
C. Line of Abutment
118'0"
95'11"
17'4"
16'0"
Eng. News.

FIGURE 16.

length of the bridge and parallel to it. Derricks mounted on the centering and on the east block molding platform lifted the buckets from the cars and emptied them at the points where work was in progress. Each car had room for three 2 cubic yard buckets but carried only two so that the derricks could deposit an empty bucket in the vacant space and take a filled bucket with the least waste motion. The concrete was utilized both for concrete block manufacture and for concrete deposited in place.

All of the trimmings on the bridge below the bottom of the coping, that is, the belt courses, quoin stones, chain stones, ring stones, brackets and dentils, are concrete blocks separately molded and set in place like cut stone. The molding or casting of these blocks was done on the ground and was one of the most important items of the concrete work. The blocks were made of concrete faced on the exposed sides with mortar composed of one part " Dragon " Portland Cement and three parts bluestone screenings from 3/8 inch size to dust.

In cases where the facing mortar was laid in cold weather it was protected from freezing by tacking tar paper to the forms so as to leave an air space between it and the face lagging. Test showed a difference in temperature of 15° F. between the air in the air space and the outside atmosphere.

The method of making these blocks was as follows: Forms of 7/8 inch tongued and grooved North Carolina pine, held together by iron tie rods, were used. These boxes or molds had collapsible sides and from 6 to 8 bottoms so that the block could be left standing on the bottom for two or three weeks while the sides could be removed in as many days and raised with another bottom. The molding was done on a level floor of tongued and grooved boards laid on mud sills. It was noted by the engineers that the molding platform had to be perfectly level to insure a uniform casting.

All blocks were molded with the principal showing face down, and if the block had more than one showing face the others were made against the vertical sides. No block was ever cast face up on account of the tendency of the cement to flush to the surface, making an unnecessarily rich mixture which was found invariably to cause hair cracks. The mode of procedure in detail was to place first the mortar facing and then deposit and tamp the backing of concrete. Great care had to be exercised in this work to keep the edges full and to force the concrete stones in the backing well out into the facing mortar so as to give as much

YARD FOR MANUFACTURE OF CONCRETE BLOCKS, CONNECTICUT AVE. BRIDGE, WASHINGTON, D. C.
"DRAGON" PORTLAND CEMENT USED EXCLUSIVELY.

strength as possible to the edges. Before a block was cast, the inside of the form was carefully cleaned and smeared with linseed oil. The blocks immediately after casting were covered with bags or old carpet and kept thoroughly wet by sprinkling. After hardening about three weeks the blocks were removed from the bottoms of the molds and placed in the storage yard to season.

The backs of the blocks had holes gouged out while the concrete was yet soft to give the stone a good bond with the concrete backing. After the blocks had hardened from 30 to 60 days, they were bush hammered on the showing faces; the ornamental stone were bush hammered by hand and the square blocks by pneumatic hammers. After the concrete deposited in place had hardened it was bush-hammered like the blocks. It was found that the "baby surfacer" was the most satisfactory tool for the work. There is practically no difference in the appearance of the block by hand and by machines, but the machine work is considerably more economical.

The making of dog holes in the blocks was performed by picks when the blocks were three or four weeks old. When it was not practicable to use dogs, two-pin lewises were used. The lewises had to be somewhat larger than for granite and care had to be taken to decrease the pressure on the interior edge of the concrete at the top of the hole.

All parts of the bridge, except the cast block trimmings were made of concrete deposited in place in suitable forms. The concrete blocks were placed first and the concrete deposited in place was formed around and back of them. The forms for this work consisted of tongued and grooved lagging held by 2x8 inch studding on 18 inch centers; this studding being supported in turn by waling timbers spaced 8 feet on centers and held in place by rods going through the walls. These rods were in two pieces connected by a treaded-shoe set about 3 inches in from the showing face of the work. This arrangement enabled the front section of the tie rod to be screwed out of the concrete and the hole to be filled with mortar. The lower parts of the arch rings were built up with piers, they being shaped by curved forms held back to the piers by wall ties. Sheet iron pieces were used in placing the facing mortar on the arch soffits. Similar plates were used for the facing of the vertical exposed walls. The arch rings were built, of course, on arch centers.

These centers were founded on piles, excepting for the small arches, where timber grillages were used, and for those portions

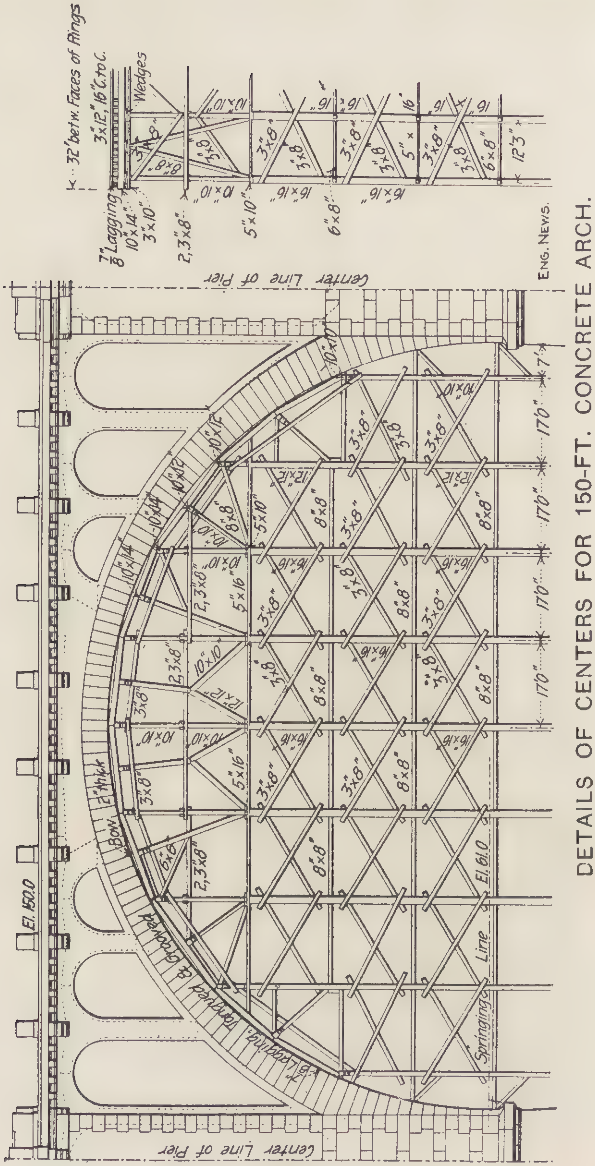

DETAILS OF CENTERS FOR 150-FT. CONCRETE ARCH.
Eng. News.
Center Line of Pier
Center Line of Pier
El. 150.0
El. 61.0
Springing Line
7/8" Lagging, Tongued & Grooved
Bow, 2" thick
32' betw. Faces of Rings
3"x12", 16" C. to C.
Wedges
7/8" Lagging

FIGURE 17.

in the line of the creek and under the iron bridge that crosses beneath the arch bridge, where concrete footings were used, founded on hard rotten rock. The centers were composed of Georgia pine, except a few struts which were Virginia pine, and the sills, caps and wedges which were of white oak. Before framing, the centers were laid out to full size on the floor of the Washington Convention Hall, and a pattern was made for each piece. The arch stones were outlined on this same lay-out and templates made for them.

New York Stock Exchange, Broad St., New York City. Over 25,000 Barrels "Dragon" Portland Cement Used in its Construction.

An Engineering Feat

Extracts from article published in the New York Tribune, July 7, 1901.

New Stock Exchange Building, New York.

The building that for years held the pulse of finance in the United States—the New York Stock Exchange in Broad and New Streets—has been torn down and in the ruins an army of busy workmen is engaged on the foundations of a new exchange.

The general public has always had more than ordinary interest in the Stock Exchange, with its " bulls and bears," wonderful fortunes made in a day and its occasional failures. The interest extended to the building in which the Wall Street brokers transacted their business. Crowds watched the work of destruction and still larger crowds take frequent looks at the foundation laying, now under way. * * * The contractors for the new Stock Exchange building are having a great deal of trouble in following the advice given in the Scriptures to found all worthy structures on rock. The rock at this particular point on Manhattan Island is covered with many feet of sand, and quick-sand at that. At a depth of twelve feet water begins to rush into excavations which may be made. Rock bottom is not found until a depth of fifty feet has been reached. The men who planned the new building knew this, and decided that four floors below the street level could be used to advantage for the machinery of the building, the vaults and rooms for employees. Having decided upon this arrangement the architects left the problem of carrying it out in the hands of John F. O'Rourke, an expert engineer and foundation contractor. He found that it would be necessary to depart from ordinary methods of constructing foundations and decided to build a continuous concrete dam around the entire site. It is said that such a foundation dam has never been built before. The dam will be fifty feet deep, eight feet wide, and will rest on the solid bed rock, making a reservoir that will be proof against water and sand.

For the building of this continuous dam, caissons are now being sunk on the boundaries of the site. These caissons are ob-

TELEPHONE 5346 CORTLANDT

John F. O'Rourke,

Consulting and Contracting Engineer.

PARK ROW BUILDING, Rooms 2137-38

New York, July 18th 1901.

Frank E. Morse Co.,
17 State St, New York.

Gentlemen:-

Your favor of the 17th inst. at hand. I beg to say that we have already used a large quantity of your cement at the New York Stock Exchange in the construction of the water-tight dam which is to enclose a cellar about 54' below curb, and that so far all the cement has been strictly first-class, and the concrete made with your cement has been of a quality that I have never seen surpassed. In my opinion, your cement is better than the usual first class Portland cements, and fully the equal of the very best. It gives me great pleasure to say that, if I had to select a cement again for this work, keeping in view the necessity for obtaining a concrete that would be both hard and water-tight, I would select your cement without any consideration of the cost.

It may interest you to know that we have yet to find one bag which was not in first class condition.

Very truly yours,

John F. O'Rourke

long in shape and measure thirty feet long, eight feet wide and fifty feet deep. They are built of wood and iron weighted with from fifty to one hundred tons of cement or pig iron. Fifteen men work in a chamber at the bottom of each caisson. Compressed air is supplied from machines on the surface in sufficient quantities to keep back the sand and water which would otherwise fill the chambers. As the laborers dig away the earth it is taken to the surface in buckets. The weight of the iron and concrete on top of the caissons keeps pushing them down. When they finally rest upon the rock bottom the work of building the dam can begin.

A number of circular caissons are being driven in various parts of the site. They are from six to nine feet in diameter, and in them will rest the steel columns which will help support the building. As soon as these are in place and the outer foundation dam is built, the cross-beams of steel will be put in place. Then excavating will begin. If these cross-beams were not placed first, the outer wall or dam would be pushed in by the weight of the surrounding buildings. The excavation will be carried on one floor at a time, and cross-beams will be placed every twelve or fifteen feet. By the time the excavating is ended the foundation will be practically completed.

"DRAGON" Portland Cement was used by the contractors for this important work.

(See Mr. O'Rourke's opinion of "DRAGON.")

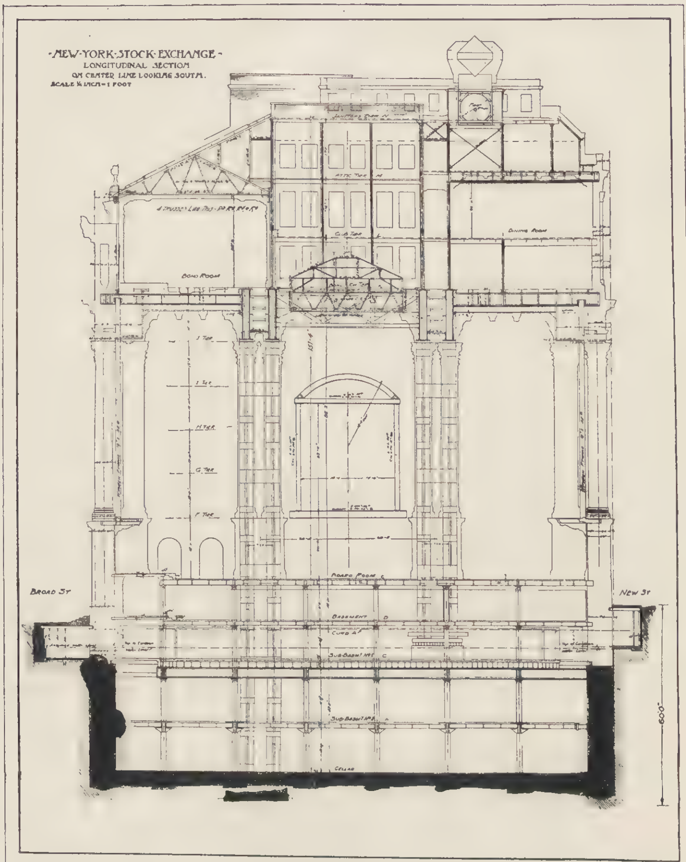


FIGURE 18.

NEW YORK STOCK EXCHANGE, LONGITUDINAL SECTION. HEAVY LINE INDICATES WORK DONE WITH "DRAGON" PORTLAND CEMENT.

Extract from The Engineering Record, April 4, 1908, with regard to Foundations of New York Stock Exchange.

In a number of important buildings the excavations have been made deep enough to permit of the construction of three or four stories below the surface of the ground and thus involve retaining walls of enormous strength and require special waterproofing to resist the tremendous exterior pressure of the quicksand and water, under a hydrostatic head of sometimes more than 50 feet.

The Stock Exchange building has a cellar floor 54 feet below curb and 42 feet below ground water level, and it was decided to build the exterior caissons first, and to connect them so as to form a continuous concrete wall around the lot excluding the ground water and enabling the interior to be drained by pumps so that the foundations there could be carried down in open cofferdams. The exterior caissons had a uniform thickness of 8 feet, an average height of about 50 feet, including the permanent wooden cofferdams continuous with their walls, and were from 24 to 30 feet long. They were of special construction, with removable domed steel roof plates and vertical wall planks and were delivered at the site in complete sections weighing about 30,000 lbs. each.

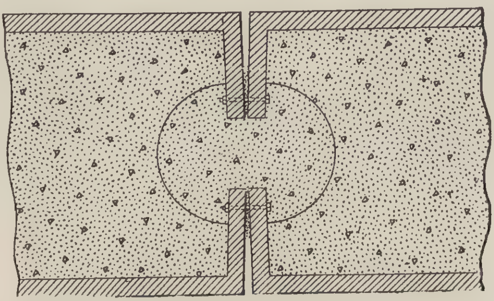
They were sunk to rock at an average depth of about 50 feet and the cutting edges were puddled with clay and a 6 inch layer of concrete was rammed over the bottom and allowed to set under pneumatic pressure, balancing the outward hydrostatic pressure due to the 40 feet head of exterior ground water. The caissons were sunk very close together with great accuracy, and when they were concreted, semi-circular vertical shafts 4 feet in diameter, were formed at the ends of the cofferdams and smaller ones on the same line in the working chambers. Afterwards men entered the shaft and removed the center planks, thus throwing the two adjacent shafts into one of elliptical cross section, which was filled with rammed concrete, making a massive water-tight key which effectively bonded the two caissons together.

In cross sections, the keys were about 4 feet wide and 5 feet long, with semi-circular ends connected by the neck formed by

Cofferdam, Caisson and Air-Lock, Stock Exchange Building.
"Dragon" Portland Cement Used Exclusively.

the end walls of the caissons, thus having an outline which closely resembled the section through the longitudinal axis of a rivet with two button heads. Before these shafts were connected, horizontal holes were bored through the adjacent walls of the cofferdams and caissons, and bolts were inserted and drawn up as tight as possible, making the openings between the planks so small that they were later easily caulked with oakum when necessary.

The interior caissons were sunk long before the main excavation was completed and temporary cofferdams were carried up to the surface of the ground to exclude the earth and enable the steel columns to be erected before the excavation of the earth caused too great an unbalanced pressure on the opposite faces of the wall caissons. After a large weight of steel had been assembled and considerable stress developed in the lower sections of the columns, the excavation was continued and great care was taken to brace the wall caissons to them and across the full width of the building with special distributing girders and adjustable connections to secure positive bearings on the faces of the caissons.



Wall Caisson Connection, Stock Exchange.

FIGURE 19.

McGraw Building, West 39th St., New York City.
(Home of The Engineering Record.)
Reinforced Concrete Construction Throughout.
"Dragon" Portland Cement Used Exclusively.

The Construction of the Thirty-Ninth Street Building, New York

Abstract from an article in Engineering Record April 4, 1908, by E. P. Goodrich, Codsulting Engineer, New York.

What is probably the best example of the highest evolution of the art of erecting high buildings of reinforced concrete exists in the heart of the metropolis of this continent and houses a great publishing company, the home of the McGraw Publishing Company. Besides being somewhat unique in its environment and occupancy, it is especially so from a structural point of view. The building was designed to be mainly occupied as a printing establishment. That fact dictated a structure as fire proof as possible. The building had, at the same time, to be so designed as to be available for office purposes. Heavy loads would have to be carried on the lower floors and printing presses might be located on any of the other floors.

Besides being designed to accommodate such conditions as those above described, a building was designed and erected which is as nearly proof against the forces of nature—even those of conflagration and earthquake—as it is within human possibility to devise.

All columns, beams, girders and floor slabs were designed as continuous, restrained members, and the reinforcement arranged with this point in view. All girders were constructed with haunches or brackets at the columns, and on the lower floors the beams which joined columns were similarly built. This was done to reduce the unit shearing stresses at those points and to diminish in a similar manner the compression stresses on the lower sides of the members, due to the negative bending moments near points of support. In almost all cases the floor slab was considered as affording sufficient top compression area for the members, except in one or two cases, where compression reinforcement was introduced.

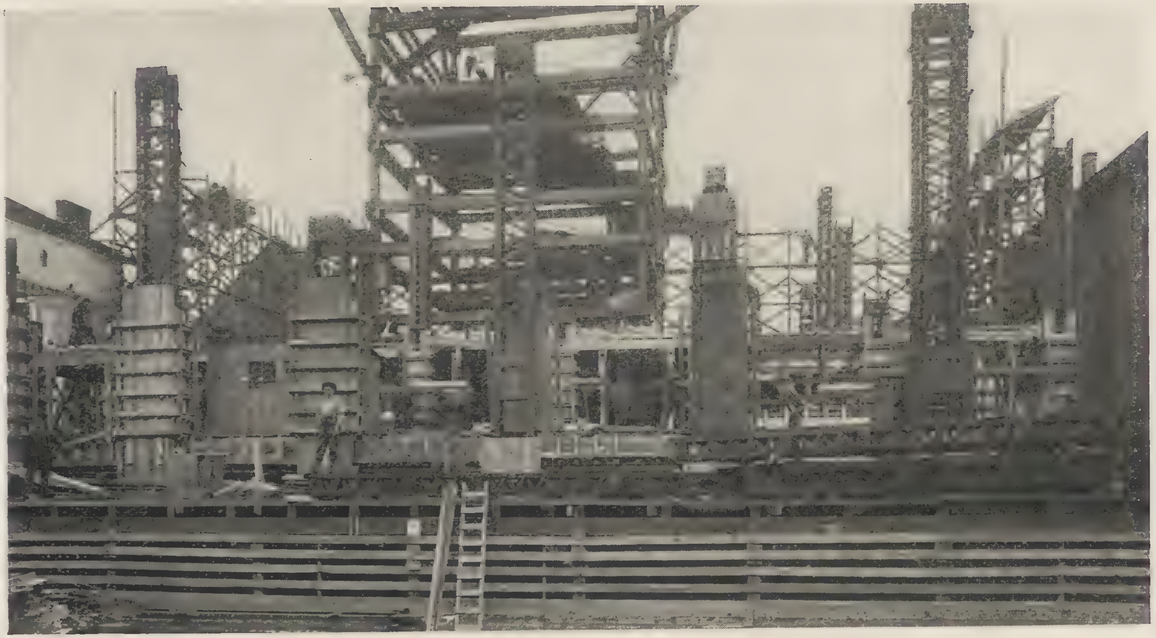
The main floor beams had spans of about 21 feet 9 inches between centers of girders, while the main girders, each of which supported two beams, had spans of about 14 feet 8 inches, less the thickness of the columns. Wall beams were carried above the floor slabs up to the window sills, thus allowing window openings to reach entirely to the ceilings, and thereby afford a maximum of light. All sharp edges of interior floor beams and girders were beveled so as to prevent chipping during construction and in case of fire, and to prevent trouble from shrinkage.

Typical Connection of Beam and Column Reinforcement, Thirty-ninth Street Building.

The reinforcing rods for beams and girders varied in size from ¾ inch to 1⅜ inch. They were of usual smooth, round variety, the only method employed of increasing adhesion or anchorage being the hooking of all ends with right-angled bends about 3 or 4 inches in length. In general, floor slabs were reinforced with ½ inch rods in as long random lengths as possible, splices being made by means of long interlocking hooks on adjacent rods, each hook being bent a full 180° turn. Over supports, alternate rods were supplied with a yoke-shaped short piece, held at a proper distance above the bottom rods by a block of concrete similar to those placed in the bottom of beams. The ends of these rods were bent downward at the theoretical points of inflection of the slabs and were hooked under the bottom rods. The concrete blocks extended over the space between three rods and were so spread and staggered that when the yoke-shaped top rods were sprung into place the whole system was held together with considerable rigidity so that it required much rough treatment to displace any rods. The latter were also supported from the forms by long concrete blocks. This whole scheme was found cheaper than wiring the rods to preserve proper spacing, especially when alternate rods are bent up over supports, as is often done.

The floor slabs were 4 inches thick on the lower floors and 3½ inches thick on those carrying the lightest live load. They had clear spans of 4 feet 4 inches. The concrete mixture employed was 1:2:4, using "Dragon" Portland cement, Cow bay sand and ¾ inch crushed trap or washed gravel. The outside walls were of concrete, without reinforcement, except in the columns and at floor levels. The 4 inch concrete walls around the smoke flue under the basement floor and around the chimney were reinforced in two directions, as is usual. A two inch air space was provided on sides and top of smoke flue under the floor, and a similar insulating air space was obtained in the case of the chimney, through the difference in form of the square shaft section and the elliptical one of the flue itself. Cement was purchased under the standard specifications of the American Society for Testing Materials and was all tested at the mill before shipment. The column foundations rested on the ledge of gneiss which runs so close to the surface in the upper part of Manhattan.

In connection with the design of the columns a modification of the Building Code, as it existed at that time, was requested and granted. Prof. W. H. Burr, who had charge of the struc-



Central Tower and First-Floor Forms Being Installed, Thirty-ninth Street Building.

tural design of the building, proposed to the Building Department that a self-supporting steel frame be employed for the reinforcement of the columns, and that it be of such size and design as to be capable of supporting the whole dead load of the structure at a proper stress. With this variety and amount of column reinforcement, which was to consist of angles battened or latticed together in a skeleton box form, it was considered that the concrete was so closely confined that its stress might safely be allowed to run higher than could otherwise be done. A value of 750 lbs. per square inch was finally selected, and the design of the building was prepared on that basis. A further condition was imposed in the design of the column reinforcement, that at each floor level the steel work in the columns must be sufficient, while acting alone and at a stress of 16,000 lbs. per square inch, to support the total dead load above that point. The structural work forming this reinforcement was often erected three stories ahead of the floor work.

The location of a sub-basement boiler room in one corner of the building produced one very long, heavy section. This one weighed 14.7 tons, and the total length of this column to the roof was approximately 170 feet. Bridge steel in accordance with Cooper's Bridge Specifications was employed for all columns.

An especially rigid connection between the column steel and the beam and girder reinforcing rods was desired. This was secured by providing on the columns shelf angles riveted to filler plates. The upper edges of the latter were gouged to proper depths and at proper spacings so as to fit the size and spacing of the reinforcing rods. These filler plates were placed with the bottoms of these semi-circular gouges just flush with the tops of the shelf angles, the horizontal flanges of which were punched to receive ½ inch bolts between each two reinforcing rods. These bolts passed through, and held down tight upon the rods, small flat iron strips, thus binding the rods firmly to the shelf angles and preventing lateral displacement because of the gouges in the filler plates. The column forms were first erected. Next, shallow troughs were put in place to form the girder bottoms and so much of the girder sides as were below the beams. Finally, boxes were set in position, which formed the slab bottoms, beam sides and girder sides combined. These boxes were provided with ledges on which to rest the 2 inch plank forming the beam bottoms, which were the last parts of the forms in-

Colgate Building, Jersey City, N. J.
Reinforced Concrete Construction Throughout.
(See interior view on page 178.)
Constructed of "Dragon" Portland Cement.

stalled, except the triangular strips which made the bevels on the edges of the beams. The sides and ends of the beam boxes were made collapsible.

The underlying motive throughout the whole work was to handle all materials in large units and masses, and to this end was provided the central tower, with four derricks on the corners.

Two electrically-driven drum concrete mixers were located in the basement so that they would discharge their contents into the elevator pits. The elevator shafts were sheathed from bottom to top, and each derrick could drop a bucket down to the mixer, wait while a batch was dumped, hoist the bucket with wide-open throttle, and when the bucket reached the proper height it could be swung and dumped within a few inches of the desired point. This method obviated the use of special concrete hoists, special hoppers, wheelbarrows or carts trundled over the forms on special runways. The booms were long enough to reach all parts of the building, each within an arch of about 260 degrees, with its center at one corner of the tower. The two front booms could reach the center of the street, and often a whole truck load of lumber, of forms or of reinforcing rods was lifted in one operation and placed practically at the required point.

Column sections were not reduced at each floor, but usually at alternate floors. In general, the forms were left in place 30 days, four complete floor sets having been provided, and an average rate of a story in twelve calendar days was maintained throughout the months from November to April, in spite of extreme weather conditions.

A scaffolding was erected across the front of the building to provide a working platform for the workman who installed the cast concrete ornamental work, the bronze faciae and the stucco finish. It was also of assistance in the erection of the concrete form work. The cast concrete ornament was set in slots and depressions molded in the mass concrete, and galvanized iron ties were employed for fastening. Moldings were run in place. Special 1/4 inch anchoring and reinforcing bracket rods were cast in the mass concrete to support heavy molded work, and dovetailed slots were formed in all surfaces where special anchors could not be placed. The stucco was of Portland cement and crushed marble and was applied in three coats to a thickness of 1 inch. The interior of the building has been plastered directly

PLEASE ADDRESS ALL COMMUNICATIONS TO THE COMPANY

The Concrete-Steel Company

Engineers and Contractors

For Reinforced Concrete Construction

29 Broadway

New York

May 17, 1907.

The Lawrence Cement Co.,
1 Broadway, City

Gentlemen:-

It affords us great pleasure to state that we used your "DRAGON" brand of cement in many of the reinforced concrete buildings which we erected in the vicinity of New York during the past year. The tests on the cement have been uniform and thus far we are very much pleased with the results.

Among the buildings erected, we might mention the new factory building for Messrs. Colgate & Company, Jersey City, N. J., which has been pronounced by many experts as one of the finest pieces of reinforced concrete work in this vicinity.

Very truly yours,

THE CONCRETE-STEEL COMPANY.

Harry L. McGee

Secretary.

on concrete, except that a patent bonding compound was first applied to the concrete surface. The main entrance is finished in imitation caen stone.

During the winter months artificial heat was provided to prevent the fresh concrete from freezing, and the latter was also mixed with hot water and the materials heated. The concrete would usually reach the point of deposit at a temperature of about 70° Fahr. Numerous salamanders burning charcoal, were provided and maintained night and day under the newest work, and even in zero weather the temperature within the enclosure made by the canvas stretched around the work never fell below 50° and was often actually found to be 100° up inside the floor boxes where the air could not circulate. The fresh concrete was always protected on top by a canvas cover held about 6 inches above the floor surface by special strips, and the hot air from below was allowed to come up and circulate in this space through the holes left in the floor for the electric outlet boxes and steam pipes. Salt hay was also spread on top of the canvas.

Colgate Building, Jersey City, N. J.
(Interior View.)
Reinforced Concrete Construction Throughout.
Constructed of "Dragon" Portland Cement.

J. B. WAILES — BOTH PHONES — J. B. WAILES

J. B. WAILES & SON

WHOLESALE & RETAIL

ANTHRACITE & BITUMINOUS COAL — PINE & OAK WOOD

GRAIN, FEED, HAY AND STRAW

LIME, CEMENT, PLASTER, SEWER PIPE, ETC.

ARLINGTON, MD. Nov. 19, 1908.

The Lawrence Cement Co.,
Siegfried, Pa.

Gentlemen:-

Feeling that it is out duty to express our views concerning your cement, we take this opportunity to do so.

When we started to handle DRAGON Portland cement it was not known in our territory. We thought this would make it hard for us to get it started.with some Contractors and Builders, because nearly all leading American brands of cement were represented and thoroughly established here.

We have found it a cement of paramount quality in every particular, it has stood very severe tests and has proven its merits by actual results and repeated orders.

To-day when asked what brand of cement we carry we are proud to say "DRAGON".

In our opinion DRAGON is just a little better than the other best brands of American Portland Cements.

Wishing your cement the success that it justly deserves, we are

Yours very truly,

J. B. Wailes & Son.

Westinghouse Lamp Company's Plant, Bloomfield, N. J.
Reinforced Concrete Construction Throughout.
"Dragon" Portland Cement Used Exclusively.

General Description of Plant of Westinghouse Lamp Company, Bloomfield, N. J.

Westinghouse, Church, Kerr & Co., Engineers & Contractors

The buildings are three in number, consisting of the main factory building, storehouse, and power house. The main building has its long axis running north and south with the other two buildings near its north end and parallel to it on the west, thus giving all buildings access from a central avenue which is carried between, and all being arranged to allow for a curve siding of large radius from the Erie Railroad which will ultimately be connected to the D. L. & W. R. R. also. The finished yard all around the buildings, with the exception of the front on Clearfield Avenue which is grass lawn, is filled with cinders to a depth of about 12 inches, making a dry surface, uniform and neat in appearance.

The arrangement for distribution of water for fire and general use is very complete; the plant being amply supplied by an artesian well 10 inches in diameter and 550 feet deep located on the property. There is also a 6 inch connection with the street main.

There are two systems of sewers, one a sanitary line that connects with the city system; the other to take off storm and drainage water.

The main manufacturing building is constructed entirely of reinforced concrete, is 521 feet by 99 feet 8 inches, three stories high, with no basement, and has a floor to floor height of 17 feet 4 inches. Columns are spaced 20 feet center to center each way and are connected by girders running across the building. Light beams on 24 inch centers run from girder to girder and support the floor slab. All floors are designed to carry a live load of 150 lbs. to the square foot.

The main girders which have a span of 20 feet center to center of columns are 29 inches deep below floor slab, the lower 19 inches, having a uniform width of 12 inches. Above this the width is gradually increased to 24 inches at the juncture with the slab. The floor beams which have a span of 20 feet center to center of girders are 10 inches deep below floor slab, 4 inches wide at the bottom and 5 inches at the top. The floor slab itself it 3½ inches thick. The columns are in section irregular octagons, four of whose faces are 9 inches wide, this dimension being maintained on the several sizes of columns. Those carrying the

First Floor Concrete, Second Floor Forms and Window Frames in Place, Westinghouse Lamp Co. Building.

second floor are 22 inches while those supporting third floor and roof are 16¾ inches between 9 inch faces. The upper end of each column terminates in a column cap of the same depth as the girder, the lower 19 inches being octagonal in section, 24 inches between 12 inch faces, the upper 10 inch being in section a 24 inch square. The reinforcement used in the girders consists of six ½ inch by 1½ inch flat steel bars 20 feet long, arranged in two banks. The lower bars of each bank are carried throughout the length of the girder and terminate in the column caps. The intermediate and top bars of each bank are turned up at suitable points to provide the proper reinforcement for shearing stresses. The ends of all bars are turned up at a right angle in order to insure a good grip on the concrete. It was also found expedient to provide at each column cap and at each junction of a girder with the outside wall, four short haunch bars of the same section as the main reinforcement. Each floor beam is reinforced with two ½x1½ inch flat steel bars 20 feet long, the lower one carried through, the upper one bent up to provide shear reinforcement as in the girder. One straight haunch bar is also provided at each point of intersection between floor beams and girders or outer walls. Since the floor slab has a clear span of only 19 inches between floor beams, no reinforcement was necessary. To provide, however, against possible cracks in the slab, four ⅜ inch round rods 20 feet long were placed in the same in each bay, these running at right angles to the floor beams.

The columns supporting the second floor are reinforced with four ¾ inch round rods on 13 inch centers, those carrying the third floor and roof with four ¾ and four ½ inch round rods respectively on 10½ inch centers, these in all cases being 15 feet long and tied together with ¼ inch steel wire every 15 inches. Each column is also tied to the column cap beneath it by four ¾ inch round rods 4 feet long. In all cases where columns bear on the ground, a footing has been provided 6 feet by 6 feet by 2 feet thick below floor slab, and reinforced with twelve ⅞ inch round rods 5 feet 6 inches long, placed in two layers, six each way.

The exterior walls are of concrete having a uniform thickness of 12 inches except under the windows on the second and third stories where it is reduced to 10 inches to form panels. The wall columns spaced on twenty feet centers are of the same thickness as the walls and are three feet in width, allowing a

Plant of Westinghouse Lamp Co., Bloomfield, N. J.
"Dragon" Portland Cement Used Exclusively.

window in each bay 17 feet 0 inches wide by 12 feet 7½ inches high. For structural reasons this construction is slightly modified at the ends of the building where two small intermediate columns are inserted in each bay, dividing the windows vertically into three sections 4 feet 4½ inches wide. Below grade the thickness of the walls is increased to 18 inches and carried to a uniform depth of 4 feet. No further spreading of the foundations was deemed necessary owing to the excellent character of the soil and to the distribution of load accomplished by making the wall columns and wall integral of equal thickness below the first floor window sill line.

In order to insure a proper distribution of loading on the outside walls, three ⅞ inch round rods were carried entirely around the building just below the first story window sills. These were laid in 20 feet lengths breaking joints on center lines of wall columns. In a similar manner two ⅞ inch round rods were carried completely around the building above the windows on each floor, the joints being broken in each case by one ¾ inch round rod 4 feet long. All wall columns were reinforced with four ¾ inch round rods in 18 feet lengths breaking joints at the various floors.

Near each end of the building and extending from the first floor to the roof a stair well is provided 20 feet square with 12 inch solid concrete walls on three sides, the building wall forming the fourth. There are also three elevator wells, the walls of which are of 12 inch solid concrete, one near either end of the building and a third approximately in the middle and on the west side. Stair and elevator wells are provided with doors at each floor, two ¾ inch round rods being placed over each. The building also contains near the north end three concrete vaults, two on the first and one on the second floors. These are each 20 feet square with 12 inch solid concrete walls and extend from floor to floor. No reinforcement is used in the walls of either stair wells, elevator wells, or vaults, except over the floors in the vault corners which take the load of columns directly above, where four ¾ inch round rods were used.

The main stairways in each stair well extending from the first to the third floor and one smaller office stairway in the north end extending from the first to the second floor are constructed of reinforced concrete. The main stairs between each two floors consist of three flights with two intermediate landings. The landings are slabs 9 inches in thickness, the flights being composed of slabs of the same thickness with the steps superimposed

Interior View of First Floor, Looking North, Plant of Westinghouse Lamp Co., Bloomfield, N. J., During Construction.
"Dragon" Portland Cement Used Exclusively.

upon them. The reinforcement consists of ⅝ inch round rods 8 inch centers in the first and third flights and on 6 inch centers in the intermediate flight. The reinforcing rods of each flight are carried across the adjacent intermediate landings so as to form a criss-cross reinforcement for these landings and at the same time to firmly anchor the reinforcement of the stairs themselves. The smaller office stairs consist of four short flights having two intermediate landings and terminating in a column landing from which a single flight leads to the second floor, both stairs and landings consisting of 9 inch slabs. The reinforcement which consists of ⅝ inch round rods on 8 inch centers in the first two flights and on 6 inch centers in the others is carried across the intermediate landings in the same manner as in the main factory stairs.

In the design of this plant special attention was given to uniformity, making the details of all parts of the structure the same, where possible, in order that the forms, which are one of the large items of cost in reinforced concrete construction, could be used over and over again and at any point desired. The forms for the lower or straight portions of the girders were made up in three sections, of 2 inch dressed plank held in place by bolts top and bottom and supported at the ends on the column forms. The beam and slab centering took the form of boxes, each box forming one section of slab and one side each of two beams. These boxes were constructed of ⅞ inch matched and dressed lumber on suitable diaphragms being placed at an angle to form the tapered upper portion of the girders. Each side of each floor box was provided with a 2x4 stringer which served the double purpose of forming the bottom of the beams and of providing a heavy member through which bolts could be inserted for fastening the boxes together in position. The ends of the boxes were carried on 2x4 members on the sides of the girders forms. Since all the beams and girders are of the same size all the centering described above was interchangeable. In designing the column centering, however, it became necessary to provide some type of form which could be used on both sizes of columns which occur in the building. This was accomplished by using a sheet iron form properly stiffened with uprights and cross bracing of wood, made up in four sections. Since the 9 inch faces remain the same on both sizes of columns the junctions between the four sections were made in the center of the other four faces, the forms being designed for the smaller columns and wood fillers being inserted when it was desired to use them for

Hall and Stairway, Plant of Westinghouse Lamp Co., Bloomfield, N. J.
"Dragon" Portland Cement Used Exclusively.

the larger size. The forms for the column caps were made in two sections of 2 inch dressed plank.

The forms for the outside walls, stair wells and vaults were made of 7/8 inch matched and dressed lumber in panels of convenient size and stiffened with rough 2x4 and 4x4 bracing. All centering was held in place by bolts of suitable length.

In putting in the outside walls the window and door frames were concreted in place by making them a part of the centering.

In building this plant the following mixtures of concrete were adopted. Foundations 1:3:6; all reinforced concrete work except columns on first and second floors 1:2½:5; columns on first and second floors 1:2:4. The outside walls and interior columns were cast by themselves, the girders, beams and floor slab being cast as a whole.

All concrete was mixed in two concrete mixers and delivered at the various floor levels by two concrete hoists. Stone and sand were unloaded from cars and delivered to the mixers by two stiff-leg derricks.

The construction of the roof slab is exactly similar to that of the second and third floor; it being level and of sufficient thickness to be used for a fourth floor in case it was at some future time desired to erect an additional story on the building. All columns and walls are designed to carry the load of such addition, should it ever be made. At present the necessary pitch to the roof is obtained by placing a dry cinder fill directly on the slab, the same being graded to a maximum depth of about 16 inches. Over this cinder fill is placed a coating of cement mortar of sufficient thickness to give a solid foundation for the four-ply tar and gravel roof which is applied thereto.

One particularly noteworthy feature of this building is the very large window area and the admirable lighting consequent thereto.

The large windows which are 17 feet wide by 12 feet 7½ inches high, are divided into four sections vertically and three horizontally.

These windows are glazed with ribbed glass throughout except the lower sash in the manufacturing portions of the building where the State law requires clear glass to be used. The upper and lower sections are designed to swing out, being hung at the top and independently operated. The intermediate section is stationary. In the office, the windows are double hung with transom sash above, clear glass being used in the windows and ribbed glass in the transoms.

The entire interior except the office is finished in white cold water paint with a 5 foot dado of dark slate color on all walls and columns. In the office, the ceilings were made flush by the use of metal lath applied to under sides of the floor beams, both walls and ceilings being finished in white plaster.

The storehouse is a building 141 feet x 79 feet 8 inches four stories high, with no basement and has a floor to floor height of 12 feet at the first story and of 11 feet 4 inches at all other stories. A bridge of steel and concrete joins the fourth floor of this building with the third floor of the main building.

Owing to the similarity of construction the same forms were used in this as in the main building, only a few of those for the outside walls having to be altered.

Miscellaneous Cost Data

Cost data in general is of value only to show through comparisons with regard to localities and sizes of enterprises, how much money is involved. Under such conditions the following information has been collected from a large number of sources (principally the technical magazines), and it is here given for the benefit of young engineers and architects who desire general information with regard to concrete construction. Like all published cost data it must be USED WITH JUDGMENT, but it is hoped that it will be of value to many because the results were obtained from actual structures.

It is well known that the cost of materials and labor in different parts of the country varies somewhat. But having the unit items all subdivided into their elementary parts, it is an easy matter, after determining the cost of materials in any locality, to make the exact correctness to the results obtained on a previous job. Similarly, when a difference in the rate per hour for wages is known, if the same efficiency is obtained from the men, it is very easy to make a correction, or if the efficiency varies, judgment must be applied to determine the correct rate to use. It has been the experience of one large New England company that, although the rate of wages and cost of materials vary somewhat in different parts of the country, the variations frequently offset one another so nearly that the sum total of the unit cost obtained in one place may be used in another, very seldom needing correction. For instance, within one month, after careful investigation, a bid was made upon a structure at San Juan, Porto Rico, using the same unit costs as for a building in Boston.

A laboratory equipment................	$250.00	to	$350.00
A laboratory man per month............	100.00	to	200.00
Cost of testing per sample.............	3.00	to	5.00
Cost of testing per barrel...............			.03
Cost of testing per cu. yd...............	.03	to	.05
Cost of washing sand per cu. yd.........	.15	to	.20
Cost of quarrying trap per cu. yd........	.58	to	.75
Cost of quarrying limestone per cu. yd....			.76
Cost of quarrying cobblestone per cu. yd..	.33	to	.37
Cost of quarrying conglomerate per cu. yd.			.89
Cost of erecting stone bins and setting up jaw crusher........................			75.00
Excavating, screening and washing gravel, cu. yard........................	.23	to	.30
Plant for screening and washing gravel...			$25,000.00
Unloading stone from scows with grab bucket, per cubic yard................			.05
Loading stone into wheelbarrows per cubic yard of concrete.....................			.05
Loading sand into wheelbarrows, per cubic yard of concrete.....................			.04
Loading cement into wheelbarrows, per cubic yard of concrete...............			.02
Loading concrete into wheelbarrows, per cubic yard..........................			.12
Wheeling materials per cu. yd. concrete, 4c., plus 1c. for each 25 ft. wheeled.			
Carting materials per cu. yd. concrete, 5c., plus 1c. for each 100 ft. haul.			
Wheeling concrete, 16c. plus 1c. for each 25 ft. wheeled.			
Mixing concrete mortar by hand per cu. yd. concrete per turn................			.02
Mixing concrete by hand per cu. yd concrete per turn......................			.05
(Example: 3 turns mortar plus 4 turns concrete equals 3x2 plus 5x4 equals 6 plus 20 equals 26c.)			
Spreading concrete dumped from wheelbarrows per cu. yd..................	.05	to	.10
Spreading concrete various other conditions per cu. yd.....................	up	to	.15
Superintendence per cu. yd. concrete......	various		

Example of estimate:

Loading stone from pile.......	.10
Loading sand................	.04
Loading cement..............	.02
Wheeling 100 ft. (4 plus 4)...	.08
Mixing mortar 3 turns........	.06
Mixing stone and mortar 4 turns	.20
Loading concrete into barrows..	.12
Wheeling concrete 75 ft. (16 plus 3)..................	.19
Spreading concrete...........	.08
Ramming concrete............	.10
Foreman (if 30 yds. placed per day)	.10
	$1.09)

Cost of trestle per ft..................		$1.50
Cost of steel cars, each................		$200.00
Cost of turn tables, each...............		$30.00
Cost of switches.....................		$20.00
Cost of cableway....................	$4,000.00 to	$5,000.00
Cost of cableway on traveling towers extra .		$1,000.00
Rubble concrete in Hemet Dam, California per cu. yd. some as low as............		4.00
Asphalt concrete 4" thick for dam lining per sq. ft.........................		.15
Tar concrete sub. floor 4½" thick, sq. ft...		.10½
Removing efflorescence with acid, sq. ft...		.07
Removing efflorescence with wire brushes, sq. ft...........................		.27
Bush hammering by hand, sq. ft.........	.01½ to	.02½
Bush hammering by pneumatic hammers sq. ft...........................	.00½ to	.01
Bush hammering for Connecticut Avenue Bridge, sq. ft.....................		.26
Tooling concrete surfaces sq. ft.........	.03 to	.12
Cost of framing and erecting retaining wall forms per m. ft. B. M.........	6.00 to	7.00
Removing same......................	1.50 to	2.00
When removable panels are used this may be as low as......................		.50

Cost of 25 ft. Raymond concrete piles in New York City per ft.	.38 plus profit.
Cost of 25 ft. Raymond concrete piles Salem, Mass., per ft.	.16 plus profit.
Cost of concrete filled caissons per lin. ft. 6 ft. in diameter.	$12.00 to $16.00
Concrete piles at Atlantic City, forms per pile, material	$3.90
Reinforcement	6.60
Pipe	2.65
Concrete material	4.42
Form labor.	3.75
Concrete labor	3.38
Removing forms, etc.	1.81
Jetter piles.	3.00
Water, plant, superintendence.	7.09
Total per pile.	$36.60
Total per foot.	1.41
Rolled (Chenoweth) piles, materials.	$59.33
Labor making.	1.20
Total per pile.	$60.53
Total per foot.	1.00
Concrete at Staten Island 12″ thick in gun implacements per cu. yd.	5.50
6″ thick, per cu. yd.	6.25
At Tampa per cu. yd.	5.75
Cost of hand mixing (actual example) (9,000 cu. yds., per cu. yd)	.82
Cost of machine mixing (actual example) (4,000 cu. yds., per cu. yd)	.47
Cascades Canal lock walls (per cubic yard)	
Hand mixing. . . . . at	$1.088
Placing with derrick. . . . . "	.798
Machine mixing. . . . . "	.388
Placing by chute. . . . . "	.459
Total average cost of concrete material.	5.266
Plant and superintendence.	1.673
Coosa River locks, with labor at $1.00 per day, concrete per cubic yard. . . . . at	4.57

Illinois & Mississippi Canal per cu. yd, lock labor.	
Mixing and placing	$1.47
Carpenter work	1.10
Materials	9.05
Superintendence and plant	.62
	$12.24
Another	8.48
Another	8.90
Another	9.06
Another	8.40
Breakwater at Marquette, Mich., under water with buckets.	
Labor	1.782
Material	4.567
Total per cubic yard	$6.348
In bags, material	5.280
Labor	1.477
Total per cubic yard	$6.757
Moulding footing blocks, material	5.23
Labor	2.478
Total per cubic yard	$7.708
Mass concrete in place: materials	3.046
Labor mixing	.695
Labor placing	.371
Total per cubic yard	$4.112
Subaqueous concrete block pier, Superior Entra, Wis.	
Material	3.2166
Labor	.5861
Plant	.8400
Total per cubic yard	$4.6427
Dam 6 feet high at Rock Island Arsenal	
Total cost of concrete per cubic yard	$3.841

A bridge pier in 5 ft. of water

Erecting and removing derrick	$70.00
Cofferdam 14x20 feet	284.00
Excavation	33.00
960 ft. foundation piles in place	176.00
100 cu. yds. concrete	466.00
Concrete forms	106.00
Rental of plant	120.00
	$1,252.00
Cost per yard of concrete	12.52

Concreting caisson of Williamsburg Bdg. above roof:

Materials per cu. yd	3.39
Labor and plant	1.69
General expense	.51
Total per cubic yard	$5.59
Concreting shaft, materials	2.92
Labor, plant and general	2.55
Total per cubic yard	$5.47

Williamsburg Bridge, in working chamber (some mortar used)

Material	3.42
Labor	6.21
Plant and general	3.10
Cost per cubic yard	$12.73

Piers Calf Killer River Bridge:

Unloading material, per cu. yd., concrete	.19
Building bins, forms, etc	1.98
Cofferdam excavation	.25
Cofferdam concrete	.38
Mixing and placing pier concrete	2.78
Removing forms	.45
Engineering, etc	.43
Total per cubic yard for 460 cu. yds	$6.46

21 concrete piers for Kansas City, Mexico & Orient Ry., 1-3-5 mix:	
Machinery and supplies	.69
Cofferdams	1.60
Forms, etc	.36
Concrete materials	3.47
Mixing and placing concrete	1.53
Excavating	.49
Miscellaneous	.67
Total per cubic yard	$8.81
Cost of concrete structures along Kansas City Outer Belt & Electric Ry.	
Form building and removing	$1.98
Mixing and placing concrete	.74
Placing reinforcement	.10
Wire, nails, water, etc	.20
Cement	1.93
Sand	.36
Stone	1.34
Lumber	.49
Total per cubic yard	$7.14
On special structures of above work, costs varied from $6.23 to $8.08.	
Chicago Drainage Canal Retaining Wall:	
Quarrying, crushing and handling stone, mixing concrete	.975
Sand	.465
Cement	1.168
Plant	.407
Total per cu. yd. for 23,568 cu. yds	$3.015
Total per cu. yd. for 44,811 cu. yds. on another section	3.225
Track elevation at Allegheny, Pa.	
Hand mixing per cu. yd.	.60
Machine mixing "	.364
Placing by wheelbarrows above foundations "	.525
Placing by cars and derricks above foundations "	.399
Placing by hand in foundations "	.175
Placing by machine in foundations "	.210

Cost of heavy retaining wall:	
Materials	$2.02
Laying	1.03
Lumber	.48
Form	.53
Handling materials	.17
Machinery and superintendence	.11
Total per cubic yard	$4.34
Pavement base in New York City:	
Hand mixing and placing	.51
Materials	2.76
Cost per cubic yard	$3.27
Pavement in New Orleans:	
Labor (hand mixing) per cubic yard	.39
Toronto:	
Materials	$3.81
Labor (hand mixing)	1.03
Cost per cubic yard	$4.84
Champagne, Ill.	
Material	$2.04
Labor (hand mixing)	.35
Cost per cubic yard	$2.39
St. Louis (for street railroad tracks):	
Materials	$2.92
Mixing (machine) and placing	.26
Total per cubic yard	$3.18
Cement sidewalks:	
Toronto, 6 ft. walk per sq. ft.	.107
Toronto, 4 ft. walk " "	.120
Quincy, Mass., 6 ft. walk " "	.14
San Francisco, 3 ft. walk " "	.10
San Francisco, 4 ft. walk " "	.14
Average in Iowa " "	.08
Average in vicinity of New York in suburbs " "	.12

Curb and gutter:	
Ottawa 14 inch gutter (per lin. ft.) labor	.230
Material	.277
Tools	.030
Total per lin. ft	.537
Champagne, Ill., per lin. ft	.45
Lining tunnel on railway near Peekskill, N. Y.:	
Concrete materials per cu. yd	$3.958
Lumber	7.69
Labor	4.121
Miscellaneous	1.864
Total	$10.712
Per ft. tunnel (275 total)	79.60
Cascade tunnel Gt. Northern Ry. per lin. ft	44.00
Hodges Pass tunnel, Oregon Short Line	25.00
Gunnison tunnel:	
Materials	4.116
Labor on forms	.498
Labor on concrete	2.539
Total per cubic yard	$7.153
Per lin. ft	10.00
New York Subway (one special section)	
Foundations per cubic yard	4.61
Roof and side walls per cubic yard	7.69
Concrete slab highway bridge, Green Co., Iowa:	
Cement	$2.26
Steel	1.22
Lumber	.22
Gravel, etc	.76
Labor	1.41
Coal	.03
Cost per cubic yard	$5.90
Girder Highway Bridge:	
Materials	$5.12
Erecting forms	2.81
Taking down forms	.20
Labor	1.50
General	2.00
Cost per cubic yard	$11.64

Another:

Materials	$6.13
Erecting forms	4.73
Taking down forms	.61
Labor	1.86
General	1.60
Cost per cubic yard	$14.93

Elkhart, L. S. M. S. Ry., 3 arches at 30 ft. span:

Temporary buildings	.15
Machinery, pipe, etc.	.08
Sheet piling	.21
Excavating and pumping	.33
Arch centers	.73
Cement	1.84
Stone	.36
Sand	.05
Drain tile	.02
Labor	1.68
Steel Rods	.63
Engineering, etc.	.11
Cost per cubic yard	$6.19

Grand Rapids, 7 highway arch spans at 75 feet:

Engineering, per cubic yard concrete	.515
Pumping, per day	9.00
Excavating	not given
Filling, per cubic yard	.27
Removing old work	not given
Hand removal, per lin. ft	2.04
Wood block pavement, per sq. yd	2.54
Steel, per lb.	.0324
Centering, per cubic yard concrete	2.09
Forms, per cubic yard	3.75
Concrete, per cubic yard	6.25

Arch Culverts on N. C. & St. L. R. R.

Span 5′, cost per cubic yard	$6.64
" 7.66′, " " " "	5.54
" 10.′ " " " "	5.89
" 12.′ " " " "	4.97
" 12.′ " " " "	5.19
" 16.′ " " " "	4.97

Pennsylvania span:

Span 3′, cost per cubic yard	$6.38
Cost 26′, cost per cubic yard	4.54

Concrete Arch Bridges:

Place Over	Plainwell, Mich Kalamazoo River	Connecticut Ave., Washington Rock Creek
Total length		1,341.0
Arch spans	45.0	2 at 82, 5 at 150
Width	45.0	52.0
Rise of Arch		41.0
Total cost	$10,500.00	$850,000.00
Cost per sq. ft.	5.20	12.20
Cost per cu. yd	2.90	10.63
Date erected	1902	1905

ESTIMATED COST OF CONCRETE BRIDGES FOR ELECTRIC ROADS.

Span, 50 ft.; width, 28 ft.

Steel 27,700 lbs. at 2½ cents	$692.50
Steel, placing 27,700 lbs. at 1 cent	277.00
Formwork at $1 per cubic yard	370.00
Cement, 481 bbls. at $2.00	962.00
Sand, 185 cubic yards at $1.00	185.00
Stone, 370 cubic yards at $2.00	740.00
Mixing and placing 370 cubic yards at $1.50	555.00
	$3,781.50
Incidentals add 15 per cent	557.22
	$4,348.72
Profit add 10 per cent	434.87
	$4,783.59

Span, 75 ft.; width, 28 ft.

Steel, 38,800 lbs. at 2½ cents	$970.00
Placing steel, 38,800 lbs. at 1 cent	388.00
Formwork at $1 per cubic yard	740.00
Cement, 962 bbls. at $2.00	1,924.00
Sand, 370 cubic yards at $1.00	370.00

Stone, 740 cubic yards at $2.00	1,480.00
Mixing and placing 740 cubic yards at $1.50	1,110.00
	$6,982.00
Incidentals add 15 per cent	1,047.30
	$8,029.30
Profit add 10 per cent	802.93
	$8,832.23

Span, 100 ft.; width, 28 ft.

Steel, 55,650 lbs. at 2½ cents	$1,391.25
Placing steel, 55,650 lbs. at 1 cent	556.50
Formwork at $1 per cubic yard	1,008.00
Cement, 1,310 bbls. at $2.00	2,620.00
Sand, 504 cubic yards at $1.00	504.00
Stone, 1,008 cubic yards at $2.00	2,016.00
Mixing and placing 1,008 cubic yards at $1.50	1,512.00
	$9,607.75
Incidentals add 15 per cent	1,441.16
Profit add 10 per cent	1,104.89
Total	$12,153.80

DIMENSIONS AND COSTS OF CONCRETE ARCH BRIDGES.

Place	Over	Total length bridge	Arch spans	Width	Rise of arch	Total Cost	Cost per sq. ft.	Date erected
		Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.			
Pine Road, Philadelphia	Pennypack Creek	....	2a 25.4¾	34.3¾	6.6	$8,662	$4.94	1893
Richmond Ave., Syracuse	Harbor Brook	....	12.0	49.0	2.6	2,000	3.40	1894
Eden Park, Cincinnati	Park Ave.	....	70.0	32.0	10.0	7,130	3.15	1895
Stockbridge	Housatonic	....	100.0	7.6	10.0	1,475	2.00	1895
Belleville, Ill.	Richmond Creek	....	40.0	52.0	7.0	10,500	3.90	1895
Topeka	Kansas River	693.0	5a 125.0 2a 110.0 2a 97.6	40.0	....	125,000	4.50	1896
Green and Goat Islands	Niagara	371.0	2a 103.6 1a 110.0	40.0	....	102,070	4.50	1900
Indianapolis	Fall Creek	198.0	2a 50.6 1a 55.0					
Worthington	Piney Branch	....	6a 74.0	65.0	9.6	105,340	3.70	1900
....	Quarry Road	....	24.0	26.0	5.0	3,170	5.10	1900
Washington	Rock Creek	....	80.0	28.6	14.0	21,500	9.40	1900
Wabash Co., Ind		....	80.0	27.0	15.0	17,500	8.10	1901
Forest Park, St. Louis	River des Peres	....	25.0	16.0	....	573	1.45	1902
Plainwell, Mich.	Kalamazoo River	....	45.0	45.0	....	10,600	5.20	1902
Saley St., Brooklyn	Prospect Ave.	446.0	7a 54.0	25.0	8.0	19,900	1.80	1903
Munich	Grunwald	125.0	85.0	60.0	....	21,800	4.30	1903
		720.0	2a 230.0	30.0	42.0	65,000	3.10	1904
Connecticut Ave., Washington	Rock Creek	1,341.0	2a 82.0 5a 150.0	52.0	41.0 75.0	850,000	12.20	1905
16th St., Washington	Piney Branch	272.0	125.0	25.0	39.0	42,731	6.25	1905
Dayton	Great Miami	588.0	69.0 to 88.0	56.0	....	123,170	3.70	1904
Park Ave., Newark	Branch Brook Park	243.7	132.0	74.0	10.2	84,000	4.70	1905
Connington, Viaduct		600.0	10a 50.0	16.0	16.0	52,200	5.43	1903
Greensburg, Ind.	Clifty Creek	....	80.0	16.0	12.0	2,695	2.10	....
Wayne St., Peru	Wabash River	500.0	6a 75 to 100	30.0	15.0	36,900	2.46	....
Wabash, Ind	Charley Creek	....	2a 75.0	30.0	18.0	7,000	1.56	....
Meridian St.		250.0	3a 74.0	60.0	9.0	51,000	2.26	....
E. Washington St., Indianapolis		....	65.0	57.0	10.0	10,885	2.94	....
Muncie, Ind.		....	38.0	16.0	7.6	640	1.21	....
Bangor, Me.		90.0	46.7¾ 38.2	40.0	8.7 7.6	6,500	1.80	....
Sandy Hill		1,025.0	15a 60.0	35.8	....	72,000	2.00	....
Walnut Lane, Philadelphia		585.0	233.0	60.0	....	262,000	7.50	....
Lansing, Mich.	Grand River	....	120.0	52.10	23.0	31.000	4.90	....

Yearly cost of inspection of steel bridges and concrete bridges should be about equal for the two classes of structures.

Depreciation and consequent sinking fund requirement for steel at least 5 per cent., for concrete not to exceed 2 per cent.

Cost of maintenance of timber if used:

For steel highway structure about 4 per cent.

For steel railway structure about 1 per cent.

Cost of maintenance of regular pavement or earth road:

Surface for concrete structure less than 1 per cent.

Of regular ballasted railway track less than 1 per cent.

Cost of painting:

Steel railway structure less than 1 per cent.

Steel highway structure less than 2 per cent.

Total maintenance costs aside from interest on first cost:

For steel structure from 7 to 11 per cent., depending on character of bridge and kind of flooring.

For concrete structure not to exceed 3 per cent.

Excess of steel over concrete from 4 to 8 per cent.

This is a rough average percentage figure therefore, which a company or community should allow in the first cost figure of a concrete bridge structure over the total cost of a steel structure for foundations and superstructure combined, in a true competition between the two classes of bridges. Of course the interest charge is to be added in each case. In other words, 3 per cent of the cost of the concrete structure should be compared with 7 to 11 per cent of the cost of a competing steel structure, and that type should be selected which will give the lower result.

Or, as a special example, if the lowest responsible bid for a concrete arch is $12,000, the yearly cost to the community will probably be 4 per cent (assumed interest charge) plus 3 per cent for depreciation and maintenance. Since the yearly costs for a steel structure will amount to from 11 to 15 per cent total (4 per cent assumed as above for interest) for the steel superstructure and slightly less for the abutments, then unless the steel bridge complete can be erected for from $6,000 to $8,000, its maintenance and interest charges will be greater than those of a concrete structure. That is, finally, it may under certain circumstances, be more economical to pay from one and a half to two times as much in first cost for a concrete structure as for one of steel.

In a particular reinforced concrete building, the percentage of the items entering into the cost of the reinforced concrete part of an eight-story office building was as follows: Labor, 38 per cent; cement, 15; stone and sand, 9½; lumber, 10; power, 1½; unclassified, 15. Roughly the same percentage of costs might hold through the construction of a factory.

Cost of Reinforced Concrete Completed Contract.

Kind of Building.	Job cost.	Volume in cu. ft.	Floor area in sq. ft.	Unit Cost per cu. ft.	Unit Cost per sq. ft.
Offices and stores	$181,194	1,365,830	90,474	$.133	$2.00
Offices and stores	61,646	496,780	39,840	.124	1.545
Factory	12,774	112,440	7,519	.114	1.70
Factory	44,652	746,674	49,546	.060	.902
Factory	39,830	312,000	24,960	.127	1.60
Garage	10,436	156,198	10,806	.085	1.25
Filter	19,993	149,250	19,208	.134	1.04
Fire station	6,757	44,265	2,982	.153	2.26
Observatory	3,625	9,734	657	.373	5.45
Filter	20,076	59,991	5,243	.333	3.82
Highest				.333	3.82
Lowest				.06	.90
Average				.138	1.72

Cost of Reinforced Concrete Complete Buildings.

Kind of Building	Job cost.	Volume in cu. ft.	Floor area in. sq. ft.	Unit Cost per cu. ft.	Unit Cost per sq. ft.
Storehouse	$141,755	1,714,448	168,696	$.0827	$.84
Hospital	60,800	703,692	57,654	.0865	1.05
Office building	61,646	496,780	39,840	.124	1.545
Cold storage	200,051	1,535,000	154,000	.13	1.30
Factory	19,292	212,400	15,000	.091	1.28
Factory	141,529	1,327,868	106,022	.107	1.335
Storehouse	76,796	1,140,000	146,000	.0685	.575
Manfg. bldg.	91,377	1,380,500	99,840	.067	1.01
Office	136,880	693,840	56,552	.197	2.42
Factory	13,064	105,600	8,800	.124	1.485
Factory	75,604	1,211,364	74,604	.0625	1.01
Factory	23,332	180,000	16,394	.129	1.42
Highest				.197	2.42
Lowest				.0625	.575
Average				.1088	1.27

COST OF CONCRETE COLUMNS.

Location.	Forms per square foot				Concrete per cubic foot						
	Carpenter labor.	Lumber.	Nails & Wire.	Total.	Concrete labor.	General labor.	Cement.	Aggre-gate.	Team & miscell.	Plant.	Total.
Office building, Portland, Me...	.133	.039	.001	.173	.064	.004	.087	.084	.012	.022	.273
Coal pocket, Lawrence, Mass...	.057	.024	.001	.082	.166	.003	.073	.041	.008	.016	.307
Mill, Southbridge, Mass.......	.097	.082	.002	.181	.073	.056	.107	.035	.027	.030	.328
Mill, Attleboro, Mass.........	.093	.022	.001	.116	.110	.014	.062	.038	.013	.034	.271
Mill, Southbridge, Mass.......	.080	.056	.001	.137	.108	.048	.100	.037	.013	.034	.340
Coal pocket, Hartford, Conn...	.098	.047	.002	.147	.089	.043	.069	.055	.017	.013	.286
Garage, Brookline, Mass.......	.071	.051	.002	.124	.070	.028	.072	.058	.041	.020	.289
Warehouse, Portland, Me......	.118	.016	.001	.135	.087	.027	.087	.070	.039	.025	.335
Textile mill, Lawrence, Mass...	.061	.013	.001	.075	.095	.019	.109	.027	.018	.015	.283
Highest	.133	.082	.002	.181	.166	.056	.109	.084	.041	.034	.340
Lowest	.057	.013	.001	.075	.064	.003	.062	.027	.008	.013	.271
Average of 9..............	.082	.036	.001	.130	.096	.027	.085	.049	.021	.023	.301

COST OF BEAM FLOORS OF REINFORCED CONCRETE.

Location.	Forms per square foot: Carpenter labor.	Lumber.	Nails & Wire.	Total.	Concrete per cubic foot: Concrete labor.	Ceneral labor.	Cement.	Aggre-gate.	Team & miscell.	Plant.	Total.
Power house, Greenfield	.165	.107	.003	.275	.143	.020	.109	.101	.008	.016	.397
Tar well, Springfield	.064	.041	.002	.107	.076	.005	.026	.075	.013	.040	.335
Mills, Greenfield, Mass.	.106	.061	.004	.171	.077	.011	.109	.086	.007	.055	.345
Car barn, Danbury, Conn.	.044	.051	.001	.096	.128	.013	.086	.071	.011	.010	.319
Coal pocket, Lawrence, Mass.	.072	.039	.002	.113	.056	.004	.073	.041	.009	.019	.202
Mill, Southbridge, Mass.	.067	.062	.002	.131	.137	.029	.191	.051	.038	.014	.460
Mill, Attleboro, Mass.	.062	.032	.002	.096	.171	.023	.098	.062	.021	.055	.330
Bridge, Plymouth, Mass.	.047	.050	.001	.098	.078	.019	.100	.040	.027	.010	.274
Garage, Newton, Mass.	.104	.033	.002	.134	.116	.020	.121	.084	.038	.010	.394
Mill, Southbridge, Mass.	.057	.051	.001	.109	.119	.027	.132	.037	.013	.034	.362
Coal pocket, Hartford, Conn.	.060	.033	.001	.094	.047	.023	.081	.055	.017	.013	.236
Garage, Brookline, Mass.	.105	.038	.002	.145	.160	.032	.088	.058	.041	.020	.399
Filter, Lawrence, Mass.	.048	.032	.001	.081	.102	.016	.085	.054	.012	.032	.301
Storehouse, Chelsea, Mass.	.064	.043	.002	.109	.153	.035	.115	.068	.052	.020	.443
Warehouse, Portland, Me.	.037	.029	.001	.067	.186	.030	.096	.069	.043	.046	.470
Textile mill, Lawrence, Mass.	.045	.042	.001	.088	.130	.013	.071	.037	.025	.010	.286
Textile mill, Lawrence, Mass.	.053	.033	.001	.087	.116	.033	.194	.049	.035	.015	.442
Chapel, Portland, Me.	.053	.027	.002	.082	.100	.008	.127	.091	.041	.010	.377
Highest	.165	.107	.004	.275	.186	.035	.194	.101	.052	.055	.470
Lowest	.037	.027	.001	.067	.047	.004	.071	.037	.007	.010	.202
Average of 18	.070	.045	.002	.116	.111	.020	.106	.063	.025	.024	.354

COST OF FLAT SLAB FLOORS.

Location.	Forms per square foot: Carpenter labor.	Lumber.	Nails & Wire.	Total.	Concrete per cubic foot: Concrete labor.	General labor.	Cement.	Aggregate.	Team & miscell.	Plant.	Total.
Office building, Portland, Me...	.078	.039	.001	.118	.043	.004	.087	.084	.012	.022	.252
Fire station, Weston, Mass.....	.067	.038	.003	.108	.103	.007	.092	.053	.026	.039	.320
Church, Boston, Mass.........	.067	.037	.002	.106	.146	.017	.109	.072	.020	.010	.374
Highest	.078	.039	.003	.118	.146	.017	.109	.084	.026	.039	.374
Lowest	.067	.037	.001	.106	.043	.004	.087	.053	.012	.010	.252
Average	.071	.038	.002	.111	.097	.009	.096	.070	.019	.024	.315

COST OF CONCRETE SLABS BETWEEN STEEL BEAMS.

Location.	Forms per square foot: Carpenter labor.	Lumber.	Nails & Wire.	Total.	Concrete per cubic foot: Concrete labor.	General labor.	Cement.	Aggregate.	Team & miscell.	Plant.	Total.
Bleachery, East Hampton......	.054	.027	.002	.083	.092	.007	.137	.073	.012	.046	.367
Machine shop, Milton, Mass...	.087	.027	.003	.117	.090	.033	.114	.075	.016	.034	.362
Foundry, North Britain, Conn..	.078	.046	.002	.126	.095	.021	.076	.078	.004	.022	.296
Stable, Boston, Mass..........	.064	.012	.001	.077	.101	.019	.129	.070	.020	.015	.354
Residence, Milton, Mass.......	.110	.071	.003	.184	.105	.048	.132	.080	.053	.010	.428
Power house, Pittsfield, Mass...	.029	.030	.001	.060	.131	.008	.123	.068	.013	.010	.353
Laundry, Boston, Mass........	.058	.024	.001	.083	.092	.021	.098	.089	.022	.010	.332
Prison, Portsmouth, N. H......	.068	.017	.001	.086	.073	.005	.208	.075	.006	.010	.377
Paper mill, Mittineague........	.097	.071	.002	.170	.144	.033	.143	.062	.027	.010	.419
Power house, Quincy, Mass.....	.047	.025	.001	.073	.073	.021	.159	.085	.064	.020	.422
School, Waltham, Mass........	.029	.028	.001	.058	.138	.009	.102	.078	.018	.015	.360
Foundry, Providence, R. I......	.028	.020	.001	.049	.084	.012	.114	.026	.026	.010	.272
Foundry, Providence, R. I.....	.043	.021	.001	.065	.111	.010	.128	.029	.029	.010	.317
Highest	.110	.071	.003	.184	.144	.048	.208	.080	.064	.046	.428
Lowest	028	.012	.001	.049	.073	.005	.076	.026	.004	.010	.272
Average	.061	.032	.002	.095	.102	.019	.128	.068	.024	.017	.359

COST OF BUILDING WALLS ABOVE GRADE.

Location.	Forms per square foot: Carpenter labor.	Lumber.	Nails & Wire.	Total.	Concrete per cubic foot: Concrete labor.	General labor.	Cement.	Aggre-gate.	Team & miscell.	Plant.	Total.
Fire Station, Weston, Mass.....	.116	.038	.004	.158	.100	.007	.069	.053	.026	.039	.294
Mill, Greenfield, Mass.........	.062	.038	.002	.102	.060	.011	.084	.086	.007	.055	.303
Water works, Waltham, Mass..	.137	.024	.001	.162	.146	.007	.058	.057	.014	.047	.329
Coal pocket, Lawrence, Mass...	.118	.056	.002	.176	.042	.004	.073	.043	.009	.019	.190
Mill, Attleboro, Mass..........	.103	.024	.001	.128	.129	.018	.074	.048	.017	.043	.329
Coal pocket, Hartford, Conn....	.096	.047	.002	.145	.118	.052	.097	.055	.017	.013	.350
Filter, Lawrence, Mass.........	.046	.032	.001	.079	.046	.017	.083	.054	.012	.032	.244
Italian garden, Weston, Mass...	.101	.073	.002	.176	.102	.008	.105	.081	.019	.010	.325
Stable, Beverly, Mass...........	.099	.030	.002	.131	.078	.019	.071	.062	.018	.010	.258
Residence, No. Andover, Mass..	.078	.016	.001	.095	.096	.014	.046	.050	.008	.010	.174
Observatory, Milton, Mass.....	.056	.038	.002	.096	.095	.012	.060	.187	.058	.005	.417
Office, Boston, Mass...........	.105	.030	.002	.137	.096	.033	.066	.114	.066	.005	.380
Tunnel, Boston, Mass..........	.112	.045	.005	.162	.126	.016	.066	.106	.077	.005	.330
Hospital, Waltham, Mass.......	.058	.028	.001	.087	.089	.017	.034	.063	.023	.010	.236
Residence, Boston, Mass........	.108	.036	.001	.145	.110	.015	.077	.069	.026	.005	.446
Coal pocket, Providence, R. I...	.087	.020	.001	.108	.052	.005	.102	.090	.015	.010	.274
Italian garden, Brookline, Mass.	.064	.027	.001	.092	.048	.011	.080	.071	.019	.010	.239
Highest	.136	.073	.005	.176	.146	.052	.105	.187	.077	.055	.446
Lowest	.046	.016	.001	.079	.042	.004	.034	.043	.007	.005	.174
Average of 17..............	.085	.036	.002	.128	.090	.016	.073	.076	.025	.019	.301

COST OF FOUNDATION WALLS.

Location.	Forms per square foot				Concrete per cubic foot						
	Carpenter labor.	Lumber.	Nails & Wire.	Total.	Concrete labor.	General labor.	Cement.	Aggre-gate.	Team & miscell.	Plant.	Total.
Filter, Warren, R. I.	.103	.048	.004	.155	.062	.037	.086	.068	.012	.031	.296
Tar well, Springfield	.071	.031	.002	.104	.040	.015	.094	.075	.013	.040	.277
Tunnel, New Bedford	.048	.045	.001	.094	.213	.019	.203	.092	.057	.015	.599
Filter, Exeter, N. H.	.124	.067	.002	.193	.064	.021	.071	.116	.034	.019	.325
Filter, Lawrence, Mass.	.058	.042	.001	.101	.046	.017	.083	.054	.012	.032	.244
Theatre, Portland, Me.	.081	.024	.003	.108	.112	.013	.073	.078	.003	.020	.303
Warehouse, Portland, Me.	.053	.009	.001	.063	.040	.019	.060	.070	.029	.017	.235
Residence, North Andover	.047	.019	.001	.067	.108	.006	.082	.045	.015	.010	.266
Filter, Lawrence, Mass.	.048	.035	.002	0.85	.055	.006	.039	.027	.011	.010	.148
Residence, North Andover	.065	.019	.001	.085	.087	.012	.072	.045	.013	.010	.239
Retain'g wall, Naugatuck, Conn.	.134	.047	.001	.182	.097	.018	.056	.032	.022	.010	.235
Hospital, Waltham, Mass.	.048	.028	.001	.077	.043	.019	.038	.063	.026	.010	.199
Greenhouse, Brookline, Mass.	.032	.035	.001	.068	.051	.007	.078	.043	.013	.010	.202
Hotel, Brookline, Mass.	.037	.018	.001	.056	.043	.002	.080	.054	.010	.010	.199
Highest	.134	.048	.004	.193	.213	.037	.203	.116	.057	.040	.599
Lowest	.032	.009	.001	.056	.040	.002	.038	.027	.003	.010	.148
Average	.068	.033	.002	.103	.076	.015	.080	.062	.019	.017	.269

COST OF FOOTING AND MASS FOUNDATIONS.

Location.	Forms per square foot				Concrete per cubic foot						
	Carpenter labor.	Lumber.	Nails & Wire.	Total.	Concrete labor.	General labor.	Cement.	Aggre-gate.	Team & miscell.	Plant.	Total.
Power house, Greenfield	.119	.077	.002	.198	.065	.020	.098	.092	.008	.016	.299
Eng. foundation, Taunton, Mass.	.054	.025	.001	.080	.045	.002	.065	.048	.004	.017	.181
Head gates, Shawmut, Me.	.071	.043	.003	.117	.033	.001	.074	.099	.003	.014	.224
Canal, Lowell, Mass.	.039	.025	.001	.065	.025	.011	.080	.078	.004	.042	.240
Foundation, Provincetown	.069	.043	.002	.114	.039	.004	.073	.099	.011	.049	.275
Dam, Merrimack, N. H.	.066	.037	.003	.106	.081	.008	.090	.055	.008	.031	.273
Foundation, Boston, Mass.	.011	.006	.001	.018	.035	.004	.061	.072	.006	.010	.188
Eng. foundation, Boston, Mass.	.095	.039	.003	.137	.037	.013	.061	.084	.013	.015	.223
Gas holder, Springfield	.034	.031	.002	.067	.043	.001	.061	.068	.005	.010	.188
Foundation, Providence, R. I.	.016	.011	.001	.028	.051	.002	.047	.076	.010	.010	.196
Highest	.119	.077	.003	.198	.081	.020	.098	.099	.013	.049	.275
Lowest	.016	.006	.001	.018	.025	.001	.047	.043	.003	.010	.181
Average of 10	.057	.034	.002	.093	.045	.007	.071	.077	.007	.021	.229

COST OF STEEL.

Location.	Weight.	Cost of handling.	Cost per ton.
Office building, Portland, Me.	324½ tons	$5,115.32	$15.76
Fire station, Weston, Mass.	8½ "	40.26	4.74
Mill, Chelsea, Mass	65¼ "	548.81	8.41
Coal bins, Dalton, Mass.	8½ "	61.75	7.26
Dam, Auburn, Me	55 "	506.76	9.18
Filter, Warren, R. I	19 "	102.59	5.40
Tank, Lincoln, Me	8½ "	69.38	8.16
Tar well, Springfield	15½ "	59.21	3.82
Monument, Provincetown	24½ "	136.84	5.58
Mill, Greenfield	92¾ "	1,232.01	10.20
Machine shop, Milton, Mass	20¼ "	177.16	8.75
Coal pocket, Lawrence, Mass.	28 "	461.16	16.47
Mill, Southbridge	53½ "	142.76	2.67
Mill, South Windham, Me	293 "	3,079.60	10.51
Mill, Attleboro, Mass.	49½ "	286.02	5.78
Garage, Newton, Mass.	20 "	86.55	4.33
Mill, Southbridge, Mass.	30 "	100.03	3.34
Coal pocket, Hartford, Conn	195 "	2,316.60	11.88
Filter, Lawrence, Mass.	44½ "	112.84	2.54
Warehouse, Portland, Me.	62 "	462.99	7.47
Standpipe, Attleboro, Mass.	199½ "	1,547.00	7.75
Highest			16.47
Lowest			2.54
Average of 21			8.52

Floors and columns for six-story building 91x112:

Steel at 2½c. lb.	$3.55
Cement	2.50
Gravel	1.10
Sand	.55
Lumber ready to erect (used 3 times)	1.70
Lumber erecting	1.20
Lumber removing	.35
Mixing and placing concrete	1.00
Shaping and placing steel	.45
Supervision, etc.	.25
Total per cubic yard	$12.65

Walls and roof one-story barn:

Concrete materials	$2.76
Labor on materials	1.01
Forms	3.64
Reinforcement	1.42
Fuel, foreman, etc	.23
Total per cubic yard	$9.06

Concrete wall columns for a brick building:

Concrete in place, per cubic yard	$8.07
Steel in place	2.49
Cutting old brick	.70
Shoring	.78
Cost per cubic yard	$12.04

Sewer at Medford, Mass. (about 3 ft.):

Excavation 1¼ yds. per lin. ft. (per cu. yd.)	59.3c.
Brick arch 1 cu. ft. per lin. ft. (per cu. yd.)	12.07
Concrete invert 4 cu. ft. per lin. ft.:	
Cement per cu. yd. concrete	$2.292
Labor mixing and placing	3.017
Forms	.187
Labor on gravel	.471
Carting	.592
Miscellaneous	.146
Total per cubic yard	$6.705

Conduits, Torresdale Filters, Philadelphia (9 feet diameter):

Total cost per cubic yard exclusive of excavation and profit	$10.50

Water Conduit, Newark (60 *inches*):

Total cost concrete, forms and reinforcement, per cubic yard	$6.14

Sewer, South Bend (66 *inches*):

Gravel	.774
Sand	.36
Cement	1.50
Steel	.84
Labor, mixing and placing	1.094
Moving forms	.757
Forms	.589
Plastering, etc.	.639
Tools and general	.841
Total per cubic yard	$7.394

Sewer, St. Louis (29 *feet*):

Cement, sand and stone	$3.67
Steel	1.10
Forms	1.25
Labor on concrete	.74
Labor on steel	.14
Moving forms	.25
Total per cubic yard	$7.15
Brick invert (per cu. yd. brickwork) additional	9.21

Cost of plant not here included.

Sewer, Wilmington (6 *to* 9 *ft.*):

Cement	$1.703
Stone	1.016
Stone dust	.508
Labor on concrete	.987
Labor on forms	.045
Forms	.082
Reinforcement	1.700
Plastering	.070
Total per cubic yard	$6.111

Concrete work of a 75,000 gallon buried tank:

Cement	$1.49
Stone	1.86
Sand	.60
Steel	4.76
Forms	1.85
Forms labor	2.41
Concrete and steel labor	2.65
Total per cubic yard	$15.62

Waterproofing this structure cost only $1,500.

Covered 500,000 gallon reservoir, Fort Meade, S. D.:

Stone	$3.168
Sand	.842
Cement	3.859
Reinforcement	4.959
Labor on concrete	1.721
Forms	2.960
Total per cubic yard	$17.509

Stand-pipe at Attleboro, Mass.:

About per cubic yard concrete	$14.00

Lining Reservoir, Quincy, Mass.:

Floor under layer	$4.487
Sides under layer	5.063
Top layers	5.93
Cement mortar layer between	14.42
Total per cubic yard	$29.90

Lining Reservoir, Chelsea, Mass.:

Lower layer (including lost time, plant, etc.), per cubic yard	$7.59
Upper layer (including lost time, plant, etc.), per cubic yard	8.36
Plastering and asphalt, per cubic yard	1.09
Excavation (per cubic yard earth)	3.77
Bochfilling (per cubic yard earth)	1.66
Total per cubic yard	$22.47

Cost of concrete in a silo:

Cement, per cubic yard	$2.62
Gravel and sand, per cubic yard	.92
Lumber	.48
Labor	4.60
Plastering	.64
Total per cubic yard	$9.26

CONCRETE PIPE.

In Indiana:	5″	apiece (actual cost)	.01131
	6″	" " "	.01323
In Iowa:	4″	" " "	.01000
	24″	" " "	.57500
Another:	8″	" " "	.02953
	10″	" " "	.02307
Another:	4″	" " "	.00950
	5″	" " "	.01100
	6″	" " "	.015600
	8″	" " "	.02060
	10″	" " "	.03975
	12″	" " "	.05025
Another:	4″	" " "	.09120
	5″	" " "	.01250
	6″	" " "	.01385
	8″	" " "	.02600
	10″	" " "	.03480
	12″	" " "	.05080
Another:	6″	" " "	.02060

The following table is given by the Miracle Pressed Stone Company, of Minneapolis. It is figured on a basis of a 1:3 mixture, with sand at 75 cents per yard, cement at $2.00 per barrel, and labor at $2.00 per day. The 4 to 8-inch sections are considered as 18 inches long, and 10 to 36-inch sections as 2 feet long.

Kind of Tite.	Thickness.	Cubic Ft. Sand.	Ccst of Sand.	Cost of Cement.	Cost of Labor.	Cost of Pipe.	Cost per Foot.
4-inch Bell-end.........	¾ inch	.079	.004	.011	.06	.077	.05
4-inch Straight.........	¾ "	.0633	.002	.01	.04	.044	.028
5-inch Bell.............	1 "	.232	.006	.013	.062	.081	.054
5-inch Straight.........	1 "	.1964	.005	.011	.055	.071	.047
6-inch Bell.............	1 "	.354	.01	.015	.08	.105	.07
6-inch Straight.........	1 "	.324	.007	.012	.058	.077	.05
8-inch Bell.............	1 "	.452	.015	.035	.08	.13	.086
8-inch Straight.........	1 "	.432	.01	.03	.06	.10	.066
9-inch Bell.............	1⅜ "	.695	.0194	.083	.09	.1924	.0962
9-inch Straight.........	1⅜ "	.622	.0174	.074	.0655	.1569	.0785
10-inch Bell.............	1⅜ "	.83	.025	.105	.10	.23	.115
10-inch Straight.........	1⅜ "	.68	.02	.085	.07	.175	.087
12-inch Bell.............	1½ "	1.1	.03	.18	.10	.31	.155
12-inch Straight.........	1½ "	.88	.025	.145	.07	.24	.12
15-inch Bell.............	1⅝ "	1.4	.039	.235	.11	.384	.192
15-inch Straight.........	1⅝ "	1.17	.033	.195	.08	.308	.154
16-inch Bell.............	1⅝ "	1.42	.04	.25	.12	.41	.205
16-inch Straight.........	1⅝ "	1.24	.035	.215	.085	.325	.162
18-inch Bell.............	1¾ "	1.84	.055	.28	.13	.465	.237
18-inch Straight.........	1¾ "	1.5	.045	.21	.09	.345	.172
20-inch Bell.............	1¾ "	1.95	.056	.325	.13	.511	.255
20-inch Straight.........	1¾ "	1.67	.045	.266	.10	.411	.205
24-inch Bell.............	2 "	2.75	.075	.46	.15	.685	.343
24-inch Straight.........	2 "	2.25	.063	.37	.12	.553	.276
26-inch Bell.............	2 "	3.05	.09	.52	.16	.77	.385
26-inch Straight.........	2 "	2.5	.075	.43	.125	.63	.315
30-inch Bell.............	2½ "	3.70	.101	.615	.17	.886	.443
30-inch Straight.........	2½ "	3.13	.086	.55	.15	.786	.393
36-inch Bell.............	3 "	4.90	.134	.815	.20	1.149	.575
36-inch Straight.........	3 "	4.32	.118	.72	.17	1.008	.51

National War College, Washington, D. C.
"Dragon" Portland Cement Used Exclusively.

PRICES PER 1,000 FEET AT WHICH CEMENT PIPE IS SOLD AT DIFFERENT POINTS.

Diameter	Colorado	California	Three Points in Iowa			Illinois	Wisconsin	Florida	Indiana
4-inch	$40.00	......	......	$20.00	$15.00	$16.00	$29.00	......	$18.00
5-inch	45.00	......	$23.50	25.00	20.00	18.00	......	$50.00	22.00
6-inch	50.00	$90.00	30.00	32.00	30.00	28.00	40.00	......	33.00
7-inch	......	......	40.00	42.00	40.00	35.00	......	......	42.00
8-inch	80.00	120.00	50.00	52.00	50.00	45.00	......	......	50.00
10-inch	110.00	180.00	85.00	84.00	85.00	65.00	......	......	65.00
12-inch	140.00	240.00	105.00	105.00	100.00	85.00	......	......	90.00
14-inch	......	......	175.00	175.00	......	150.00	......	......	140.00
16-inch	......	400.00	250.00	225.00	......	190.00	......	......	200.00
18-inch	......	500.00	350.00	325.00	......	238.00	......	......	250.00
20-inch	......	......	450.00	425.00	......	275.00	......	......	300.00
22-inch	......	......	550.00	500.00	......	350.00	......	......	......
24-inch	......	......	650.00	600.00	......	400.00	......	......	400.00

TABLE SHOWING RELATIVE THICKNESSES, WEIGHTS, AND COST OF "STANDARD" CAST-IRON PIPE AND CONCRETE PIPE.

Size and Kind of Pipe	Thickness in inches.	Weight lbs. per lin. ft.	Cost per lin. ft.
12 inches diameter, cast-iron..	0 33/64	75	$2.44
12 inches diameter, concrete..	2	88	0.16
18 inches diameter, cast-iron..	0 47/64	167	5.43
18 inches diameter, concrete..	3	220	0.36
24 inches diameter, cast-iron..	1	250	8.13
24 inches diameter, concrete..	4¼	420	0.68
30 inches diameter, cast-iron..	1 1/16	334	10.86
30 inches diameter, concrete..	4½	602	0.88
36 inches diameter, cast-iron..	1⅛	450	14.63
36 inches diameter, concrete..	4¾	676	1.10
42 inches diameter, cast-iron..	1⅜	600	19.50
42 inches diameter, concrete..	5¾	960	1.55
48 inches diameter, cast-iron..	1 7/16	725	23.56
48 inches diameter, concrete..	6	1131	1.83

COST OF FACTORY FOR MANUFACTURE OF CEMENT PIPE.

Building	$6,000
Grounds	500
Track system, with Chase cars 8'x40", three decks to cars	2,500
Lake City tile machine....................................	1,500
Two Lake City continuous mixers....................................	500
6x6 Chicago pneumatic air compressor, with Keller rammer, pipe and hose....................................	325
Universal Stone Crusher No. 2....................................	500
Anchor block machine with pallets....................................	350
Lake City and Miracle molds....................................	300
Electric lights (dynamo, etc.)....................................	235
Sand elevator....................................	110
Screen	50
Belt conveyor for sand....................................	100
Engine and boiler (30-horse power Erie)....................................	600
Piping	200
Sundry equipment....................................	200
	$13,970

NOTE—For an exclusive pipe factory there could, of course, be deducted from this the $350 for block machine and pallets.

Partial List of Uses of Portland Cement

A.

Abattoirs
Abutments
Air Tanks
Amphitheatres
Anchorages
Aquariums
Aqueducts
Arches
Armor for Battleships
Art Figures
Ash Pits
Assay Furnace Lining

B.

Ballast Tanks in Warships
Balustrades
Band Stands
Barrels
Base Boards
Bath Tubs
Beams
Bedding Tile Ducts
Benches
Bicycle Race Tracks
Bicycle Paths
Bins
Blacksmith Forges
Boats
Boiler Covering
Boiling Tanks
Breakwaters
Bridges
Brine Tanks
Building Blocks
Burial Vaults
Butts for Telegraph Poles
Bumpers (car)
Bungalo
Burglar Proof Vaults

C.

Caissons
Canal Locks
Capitals
Cast Stone
Cement Brick
Cement Coal
Cementine Curtains
Cement Storage Bins
Chimneys
Chimney Caps
Churches
Cisterns
Clothes Posts
Coal Handling Plants
Coal Mines
Coal Pockets
Coal Trestles
Coffin Boxes
Columns
Coping
Cornices
Corner Stones
Crossings
Culverts
Curbing

D.

Dams
Dog Kennels
Domes
Drain Pipe
Driveways
Drip and Splash Boards for Tanks
Dry Docks
Dwellings

E.

Election Booths
Electric Conduits

Pillars
Pipe
Pipe Covering
Pits, Ash
Pits, Elevator
Pits, Waterproof
Plugs for Unused Ducts
Plumbobs
Pointing Masonry
Poles, Flag
Poles, Telegraph
Poles, Trolley
Porch Blocks
Porch Columns
Porticos
Posts
Power Houses
Prison Cells
Prisons
Puddling

R.

Railbeds
Railroad Ties
Railway Stations
Reinforced Concrete (all kinds)
Repairing Boilers
Repairing Cracked Steam Head in Dinky Locomotives
Repairing Leaky Auto Radiators
Repairing Leaking Refrigerators
Repairing Masonry
Repairing Trees
Reservoirs
Retaining Walls
Rifle Pits
Rifle Targets
Round Houses
Roofs (reinforced)
Roofing Slabs
Roofing Tile

S.

Safes
Salt Mines
Sand Bins
Schools
Scouring, in Place of Sand Soap
Sea Walls
Sewage Disposal Plants
Sewers
Sewer Pipe
Shelves
Shingles
Ships
Sidewalks
Signal Towers
Sills
Silos
Slaughter Houses
Sockets Between Joints
Spandrels
Stables
Stacks
Stack Linings
Stadium
Stairways
Stations (R. R., etc.)
Statuary
Stepping Blocks
Steps
Stock Yards
Stoves (concrete)
Street Paving
Stringers
Stringers for Steel Rails
Stucco
Subways
Surfacing Roads
Sun Dials
Survey Stakes
Swimming Pools
Switch Boards

T.

Table Tops
Tanks
Tanks, Air
Tanks, Boiling
Tanks, Brine
Tanks, Gas
Tanks, Oil
Tanks, Water
Tannery Vats
Tennis Courts
Timbering Mines
Tombs
Towers
Toy Building Blocks
Transfer-Pits
Trestles
Tunnels
Turntables
Tree Cavities

U.

Urns

V.

Vats
Viaducts
Vine Props

W.

Wall Plaster
Warehouses
Warship Lining
Wash Tubs
Waterproof Pits
Water Towers
Water Troughs
Wharves
Window Sills

DRAGON
TRADE MARK
PORTLAND
LAWRENCE PORTLAND
SIEGFRIED, PA
CEMENT COMPANY
CEMENT

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